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КОНФЕРЕНЦИЯ ОРГАНИЗАЦИИ ОБЪЕДИНЕННЫХ НАЦИЙ
ПО ВОПРОСУ О ПРИМЕНЕНИИ НАУЧНЫХ И ТЕХНИЧЕСКИХ ЗНАНИЙ
ДЛЯ УДОВЛЕТВОРЕНИЯ ПОТРЕБНОСТЕЙ МЕНЕЕ РАЗВИТЫХ РАЙОНОВ

ПУНКТ ПОВЕСТКИ ДНЯ: A.5.2

ПОЛЬША

ОСВОЕНИЕ МЕСТОРОЖДЕНИЙ ПОЛЕЗНЫХ ИСКОПАЕМЫХ

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Документы, составленные для Конференции Организации Объединенных Наций по вопросу о применении научных и технических знаний для удовлетворения потребностей менее развитых районов, служат в качестве рабочих документов для этой Конференции. Они опубликованы в том виде, в каком были представлены их составителями, и их содержимое и выраженные в них мнения принадлежат их составителям (см. примечания на оборотной стороне).

ПРИМЕЧАНИЯ

1. Документы, включенные в число материалов, принятых для обсуждения на общих сессиях, будут в распоряжении делегатов Конференции на следующих официальных языках Организации Объединенных Наций: русском, английском, испанском и французском.

2. Документы, включенные в число материалов, принятых для обсуждения на специализированных сессиях, будут в распоряжении делегатов Конференции только на одном из этих официальных языков.

3. Резюме всех документов в том виде, в каком они были представлены их составителями, будут в распоряжении делегатов Конференции на следующих официальных языках Организации Объединенных Наций: русском, английском, испанском и французском.

4. До открытия Конференции документы и резюме не будут выпущены для общего распространения. Они будут опубликованы заблаговременно только в ограниченном числе экземпляров и исключительно для правительственных делегаций и других правомочных участников. Последующие опубликование и рассылка трудов Конференции будут обеспечены в соответствии с практикой Организации Объединенных Наций, как это установлено ее Издательским комитетом.

Освоение месторождений полезных ископаемых.

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1. Введение.

В современном мире отдельные страны находятся на разном уровне промышленного развития. Вызвано это, рядом с политическими и экономическими факторами и объективными причинами, к которым следует зачислить обладание залежами минерального сырья. Надлежащее использование минерально-сырьевой базы решающе влияет на совокупность народного хозяйства и является основой экономического развития каждой страны.

Мировые запасы минерального сырья разделены в настоящее время следующим образом: Северная Америка - 43,9%; Южная Америка - 7,1%; Африка - 4,7%; Азия - 5,3%; Австралия - 13%; Европа - 26%.

Польша, обладающая 10% запасов Европы, относительно богато снабжена в минеральные рессурсы, что вызвало развитие горных традиций и собрание значительного опыта по исследованию месторождений, проектированию и строительству шахт и добыче.

Капиталовложения на горную промышленность составляли в течение последних 11 лет около 21% общих капиталовложений и горное производство достигло 300% уровня 1939 года - добычи ок. 150 млн.тонн минерального сырья в год.

Опыт горной деятельности в Польше показал, что проектирование шахт в современных общественно-экономических условиях требует учета потенциальных возможностей развития эксплуатации всего месторождения и развития сопутствующего строительства, разработки проекта рационального комплексного освоения месторождения, включающего целость основных и производных проблем горной промышленности, сопутствующих промышленностей и производств посредственно связанных с горным делом - сообщения, энергоснабжения, теплоснабжения, водоснабжения, жилищного строительства и обслуживания населения. Собранный опыт, без сомнения, может быть использован странами, развивающими свое народное хозяйство.

Комплексное проектирование освоения месторождений подразделяется на две основные части:

1. Горное освоение месторождения, т.е. комплекс работ с целью определения в данных горно-геологических условиях, наиболее выгодных: типа, модели, мощности шахты, размещения шахтных полей и очередности строительства шахт на основании технико-экономических критерий.
11. Пространственное освоение округа, т.е. разработку, для данного горного округа, проектов сети сообщений, энерго-, тепло- и водоснабжения, канализации, сети вспомогательных промышленных предприятий, жилищного строительства и объектов культуральной и обслуживающей деятельности.

2. Горное освоение месторождения.

Следует точно определить границы месторождения, исходя как из природных, так и экономических факторов, его форму, структуру, запасы полезного ископаемого и общий коэффициент извлечения.

При определении запасов месторождения следует определить: основные горно-геологические параметры, как размеры залежи, удельный вес, процентное содержание ископаемого, коэффициент извлечения, гидрологический и геомеханический показатели, газоносность, пылеобразование и склонность к самовозгоранию.

Особенное внимание при проектировании следует уделить точному определению общего коэффициента извлечения, так как при слишком оптимистическом подходе угрожает недостижение проектной мощности шахт, а при слишком пессимистическом может затормозить тенденцию строительства современных, мощных и рентабельных предприятий. В Польше в среднем принимают его: для каменного угля - ок. 0.53, для соли - 0,48 и для полиметаллических руд - 0,63.

Горное освоение месторождения возможно подразделить на следующие этапы:

a/ подразделение месторождения на горные округи, создающие возможность концентрации строительства на части месторождения, гарантирующей достижение максимального экономического эффекта /рисунок №. I /;

b/ выделение, в границах горных округов, районов, в которых сходство горно-геологических условий создает возможность применения однородной, в принципе, модели шахт;

c/ определение, на основании горно-геологических условий данного района, типа и модели шахт и определение оптимальных параметров величины шахты;

разделение района на отдельные шахтные поля и установление очередности строительства шахт в районах и горном округе.

Раздел месторождения на горные округи проводится на основании геологических, географических и административных условий, а раздел округов на районы исключительно на основании горно-геологических условий. Основой анализа являются показатели, характеризирующие:

1. наносы, их мощность, структуру, гидрогеологию, газоносность и геомеханические свойства,
11. стратиграфию месторождения, форму и структуру залежи, качество ископаемого, гидрогеологические и геомеханические условия, газоносность, пылеобразование и склонность к самовозгоранию.

Выделение районов имеет основное значение для определения типа и модели шахт, отвечающих условиям месторождения и создает возможность определения оптимальной величины проектируемых шахт и последовательно раздела района на шахтные поля. Главные параметры шахтных полей определяются аналитическими методами.

3. Тип и модель шахты.

По технико-организационным факторам выделяются три основных типа шахт:

- самостоятельная шахта, в которой весь производственный процесс проходит в рамках шахтного поля данной шахты /рисунок №.II /,
- групповая шахта, называемая тоже несамостоятельной, ведущая отдельную подземную эксплуатацию, но сгруппированная с другими шахтами в производственное горное предприятие с центральной обогатительной фабрикой, другими подсобными предприятиями и управлением, находящимися за пределами шахтного поля /рисунок №.III/.

- объединенная шахта, состоящая из нескольких элементарных шахт с самостоятельными: рабочим коллективом, вентиляционной системой и закладочной установкой, связанных системой магистральных горных выработок с центральными подъемными стволами, обогатительной фабрикой, электроцентралей и другими промышленными объектами, обслуживающими производственное поле объединенной шахты /рисунок Е. IV /.

Под моделью шахты следует понимать способ расположения стволов, добычных горизонтов, определение структуры подразделения горизонтов на этажи, подэтажи, крылья и панели. Модель шахты создает подземная сеть вскрывающих горных выработок, в которые вводятся механизмы и устройства, требуемые для работы шахты.

Расположение подъемных, вспомогательных и вентиляционных стволов связано с типом шахты и в зависимости от типа выступают следующие основные схемы расположения стволов:

a/ самостоятельная шахта - центральная или фланговая с двумя вентиляционными стволами на противоположных крыльях шахтного поля,

b/ групповая шахта - на отдельных шахтных полях, как в самостоятельной шахте,

c/ объединенная шахта - подъемные стволы расположенные в центре производственного поля и комплексы стволов для вентиляции и спуска рабочих, расположенных центрально в каждом элементарном шахтном поле.

Расположение стволов имеет основное значение для проектирования пространственного освоения, в особенности для разработки проекта междушахтной сети сообщения и соединения ее с магистралями округа.

Следующим элементом значительно влияющим на работу шахты, есть определение соответственной вертикальной высоты горизонта и количества одновременно действующих горизонтов. При определении высоты горизонта следует учитывать срок выработки этажа, горно-геологические условия залежи, технические условия эксплуатации и оптимальное вскрытие всех частей месторождения при нарушенной структуре.

При вскрытии отдельных пластов на горизонте применяются две основные структуры:

i. залежная структура, называемая также классической, при которой из околоствольного двора проводят перпендикулярный к простиранию, квершлаг, вскрывающий очередно пласты, в которых проводятся следующие вскрывающие и подготовительные выработки /рисунок Е. V /,

ii. каменная структура, называемая также геометрической, при которой из околоствольного двора проводят магистральный квершлаг, а из него основные полевые магистрали, а из них квершлаги. В месте пересечения пластов квершлагами - главные штреки /рисунок Е. VI /. При пологом залегании и пластах, склонных к самовозгоранию, пласты вскрываются из квершлагов слепыми стволами.

Каменная структура горизонта создает благоприятные условия эксплуатации нарушенных и слабо исследованных месторождений, упрощает схемы транспорта ископаемого, материалов и рабочих, схемы проветривания и водоотлива, а путем создания независимых вентиляционных районов гарантирует самые лучшие условия охраны перед пожарами и их последствиями. Следует подчеркнуть, что тенденция применения каменной структуры горизонта и типа объединенных шахт отвечает техническому и организационному развитию горной промышленности, создавая возможность снижения себестоимости и увеличения производительности труда.

Современное, прогрессивное проектирование типа и модели шахт должно основываться на аналитических методах определения для данных

горно-геологических и технических условий, основных параметров шахты: суточной добычи - V_d, величины шахтного поля - P, срока выработки шахты - T и запасов полезного ископаемого - Z, при которых достигается максимальный экономический эффект при минимальном суммарном вложении труда. Таким образом всего чаще применяемым в методах определения оптимальной величины шахты критерием, является минимум себестоимости добычи.

4. Раздел района на шахтные поля. Определение очередности строительства шахт.

Определение величин добычи и шахтного поля создает возможность проведения расположения шахт в районе, с учетом натуральных границ и разработки пространственного освоения района, причем комплексное проектирование должно охватывать проекты всех шахт данного района.

Определение количества и очередности строительства шахт в районе основывается на плане развития добычи ископаемого в районе, установленном согласно с планом развития народного хозяйства и принятом сроке строительства шахты определенной мощности.

Строительство шахт подразделяется на два основных периода: вступительный, охватывающий проведение геолого-исследовательских работ, разработку: концепции горного района, эскизных проектов шахт, проектного задания шахт, первой очередности и технического проекта подготовительного периода строительства и организации подсобных предприятий, с оформлением надлежащих документов и период строительства.

Период строительства делится на два этапы:

- подготовительный, в течение которого строятся подъездные пути и дороги, подводятся линии электропередачи, водоснабжения, строится жилая площадь, нивелируется и оснащается стройплощадь, сооружаются временные и постоянные здания, необходимые для начала проходки стволов и ведения дальнейших работ на поверхности,
- основной, в течение которого проходят стволы, вскрывающие горные выработки и сооружаются объекты поверхности.

Следует подчеркнуть, что направление на строительство крупных производственных единиц считается в мировой горной промышленности наиболее прогрессивным и экономически выгодным, как с точки зрения строительства, так и эксплуатации.

Собранный нами опыт подтверждает, что комплексное освоение горных округов и строительство мощных шахт, оснащенных современными машинами, является экономически целесообразным и приводит к достижению высоких технико-экономических показателей.

5. Пространственное освоение округов.

Для достижения правильного и планируемого развития строящихся шахт, необходимо обеспечить их кадрами, материалами и энергией. Вопрос этот решает пространственное освоение округа путем строительства ряда вспомогательных, сопутствующих и обслуживающих объектов /рисунок №. VII /.

Опыт освоения округов указывает, что группа шахт, охватываемая одним проектом пространственного освоения, будет на промышленно слаборазвитой территории более большая, чем на высокоразвитой территории. Например: в Верхней Силезии поверхность горного района не превышает 100 км^2, в Надвислянском округе составляет свыше 200 км^2, меднорудный округ Любин-Серашовице достигает 1000 км^2 поверхности, а в действенных территориях СССР превышает уровень несколько тысяч км^2. По мере увеличения поверхности территории округа про-

странственного освоения уменьшается точность первых разработок и возникает необходимость разработки, в очередных этапах, проектов для территориально меньших единиц. Таким образом, в зависимости от внешних условий, некоторые разработки охватывают целий округ, а некоторые только районы.

К главным проблемам пространственного освоения округа следует засчитать сети: транспорта грузов, энергетическую, водоснабжения, канализационную, горных подсобных производств, жилищную и обслуживания.

6. Сеть транспорта грузов.

Основным грузом является ископаемое. Материали, крепь, машины и оборудование для шахт транспортируются в относительно незначительных количествах, например, в угольных шахтах; их вес не превышает 3% всей добычи. Значительный грузопоток выступает при применении гидрозакладки, достигает он, в некоторых случаях, веса ископаемого. Иногда местные условия требуют перевозки значительных количеств отходов производства.

Наиболее распространенным является нормально- или узкоколейний железнодорожный транспорт; применяется автомобильный и речной транспорти, гидротранспорт, а при малых расстояниях ленточный и канатный транспорты.

Основными данными для проектирования транспортной сети являются: максимальная величина перевозок, направление перевозок и расположение обогатительных фабрик. Местные природные условия, технические возможности и сравнение стоимости разных видов транспорта, дают обыкновенно однозначный ответ, какой вид транспорта следует применить при определенной величине грузопотоков и создавшихся условиях.

При железнодорожном транспорте следует определить наиболее выгодние: точки соединения веток с магистралями, что достигается методом вариантов, и расположение сети веток, например, геометрическо-аналитическим методом Лямхардта. Для автомобильного транспорта следует определить оптимальное расположение шоссейних дорог в округе или районе.

7. Энергетические сети.

Шахти снабжаются энергетической и тепловой энергией, а в некоторих случаях энергией сжатого воздуха. Снабжение электроэнергией в количестве до 15 млн.квтч. в год на 1000 т. суточной добичи нетто осуществляется из сети электроэнергетической системи высокого напряжения /всего чаще 110 кв./, по крайней мере из двух источников. Основними факторами правильного проектирования электроэнергетической сети снабжения является знание расположения предвидимых к строительству шахт и потребностей мощности.

Главним вопросом теплоснабжения является количество и расположение теплоэнергоцентралей в данном округе или районе. Минимальная суммарная мощность всех теплоэнергоцентралей и пиковых котельних должна отвечать суммарной пиковой потребности тепла с учетом потребности аварийной мощности. Желательно, чтобы потребность топлива не превышала количества имеющихся в расположении промпродуктов.

Тенденции надлежащего использования топлива ведут к концентрации производства энергии. Эту концентрацию ограничают следующие факторы:

- потери тепла в магистральных сетях и высокая стоимость трубопроводов на территориях подверженних сдвижению,

- допустимые расстояния пересылки аварийной мощности, которые при напряжении 6 кв. не должны превышать 6 км.,
- стоимость транспорта промпродукта и затруднения, вызываемые перевозом шлихов зимой.

При учете приведенных факторов, соответствующие технические и экономические решения находятся методом вариантов.

6. Водопроводные и канализационные сети.

Потребителей воды в горных предприятиях возможно разделить на 4 следующие группы, отличающиеся требованиями относительно качества воды:
- питьевая вода и вода для умывания, отвечающая своим качеством установленным стандартам; потребление этой воды составляет в среднем 105 л. на человека в смену,
- вода для: пополнения циркуляции охлаждения компрессоров, теплоэнергоцентралей и котельных; эта вода не может быть слишком твердой и соленой, ее количество следует определить отдельно для каждого случая,
- вода для пополнения циркуляции в обогатительных фабриках - она не может снижать качество продуктов обогащения, агрессивно действовать на оборудование и т.п.,
- вода для гидрозакладки /в случаях применения гидрозакладки/, очищенная только механически; Нежелательны такие воды, вызывающие коррозию металлов.

В принципе для каждого потребления должны быть 2 источника питания. Водоснабжение может производиться из коммунальных водопроводов /доставляющих только питьевую воду/ или шахтных водопроводных установок, использующих как грунтовые, так и рудничные воды.

В каждом горном округе имеются по крайней мере 2 независимые кольцевые водопроводные сети, создающие возможность двустороннего снабжения каждого потребительского пункта, что гарантирует поставку воды в случае аварии водопровода.

Сток вод производится двумя отдельными канализационными системами: дождевые воды непосредственно, а бытовые сточные воды через механическо-биологические фильтры. Фильтры обслуживают одновременно горные предприятия и поселки.

Следует определить степень концентрации фильтров и расположение канализационной сети, учитывая сдвижения поверхности, вызываемые горными работами. Эти задачи решаются методом вариантов, причем оседание земной поверхности влияет в сторону деконцентрации установок. Большое значение имеет правильное определение степени оседания поверхности, так как горные работы могут вызвать наклон в обратном, по отношению к принятому в проектах, направлению.

В горных округах с засоленными рудничными водами появляется, нерешенный еще до сих пор, вопрос их обезвреживания. Единственным выходом является отвод таких вод в нижнем течении рек, где не вызовут они превышения границы стандарта засоления.

В обогатительных фабриках применяются, в принципе, циркуляционные системы без отвода употребленной воды.

9. Сеть горных подсобных предприятий.

Правильное расположение в округе подсобных и строительно-монтажных предприятий и их баз, имеет большое значение для работы и ройки шахт. Расположение центральных складов и ремонтных мас-

терских должно быть запроектировано с учетом принятой схемы транспортной сети и стоимости перевозок материалов, машин и оборудования. Центральные склады должны быть расположены на границах района или округа при магистралях сообщения, а центральные мастерские в центре.

Базы строительно-монтажных предприятий располагаются с учетом возможной концентрации, в одном или двух местах, с целью снижения капиталовложений на железнодорожные ветки, дороги, энергетические линии, водопроводы, связь и т.п. и с учетом возможностей временного использования зданий и установок, предназначенных в последствии для другого употребления.

Ниже рассмотрены значительные изменения густоты населения и индустриализации округов, развивающих горную промышленность, вызывают необходимость коренной реконструкции почтовых телетехнических сетей связи. Одновременно должны быть приведены в действие разнообразные виды горной связи: административной, диспетчерской, железнодорожной, горноспасательной и т.д. В таких условиях является целесообразной совместная разработка проектов почтовой и горной связи, что приносит в результате снижение капиталовложений и упрощение эксплуатации.

10. Сеть поселения.

В европейских условиях строительство шахт почти-что никогда не ведется на территориях, имеющих свободные резервы рабочей силы, а если таковые и имеются, то это рабочие, неознакомленные с горной специальностью. Таким образом при строительстве новых шахт требуется в каждом случае приведение работников из других окрестностей и постройка поселков для них. Этот вопрос должен быть решен с точки зрения группы шахт; о расположении сети поселения решают гуманитарные и экономические критерии - следует при возможно низких капиталовложениях достичь категорически требуемую степень удовлетворения человеческих потребностей.

На расположение сети горных поселков влияют следующие основные факторы:

- поселки должны быть достаточно большими, чтобы экономически было целесообразным расположение в них основных форм обслуживания, как основные школы, детские сады, ясла, продовольственные и промышленные магазины, ремесленные мастерские и медпункты. В польских условиях минимальную величину поселка определяют на 2 до 4 тысяч жителей,
- расположение поселков должно учитывать возможность быстрого сообщения с центрами обслуживания высшего разряда,
- территории, предназначенные для поселков, должны иметь соответствующие природные условия,
- поселки не должны быть отдалены более, чем на 30-45 минут хода пешком от шахты - это имеет не только гуманитарное, но и экономическое значение, так как элиминирует дорогостоящий довоз рабочих на шахту и снижает плывучесть кадров,
- расположение поселка на территории горной эксплуатации не должно затруднять эксплуатации, а с другой стороны слишком увеличивать капиталовложения на охрану перед повреждениями, вызываемые сдвижениями пород.

Кроме вышеуказанных имеют влияние и такие факторы, как пригодность грунтов под строительство, зависимость удельной стоимости строительства от величины поселка и т.п. В Польше проявляется в настоящее время тенденция избегания строительства новых поселков, а расширения существующих. Таким образом достигается возможность размещения и представления необходимых услуг строительным бригадам.

Часть кадр шахты - инженерно-технический персонал, горноспасатели и некоторые специалисты должны быть поселены в непосредственной близости шахты.

Следует подчеркнуть, что строительство шахт в новых горных округах резко увеличивает густоту населения. Например, в новых угольных районах Польши при интенсивности добычи около 500 т. на км² и сутки, и производительности труда около 2 тонн на человека к смену, густота населения увеличивается с около 200 жителей на км² до около 1500 жителей на км². Количество трудящихся шахты возрастает постепенно; принимается, что годовой прирост шахты не должен превышать количества 500 человек. Этому постепенному приросту должен отвечать строительный потенциал жил-строительных предприятий.

Опыт освоения новых горных округов показывает, что на работу в шахтах рекрутируется 10 до 15% количества местного населения и 5 до 10% населения, проживающего на расстоянии до 30 минут проезда поездом или автобусом.

11. Подсчет экономической эффективности строительства горного округа.

Является практически невозможным подсчитать полный экономический эффект строительства горного округа в народном хозяйстве. Для определения непосредственной эффективности строительства шахты или группы шахт, с целью выбора оптимальных вариантов, употребляется в Польше следующая формула:

$$E = \frac{I + I \cdot q \cdot n \cdot + \sum_{i=1}^{n} K_i}{\sum_{i=1}^{n} P_i}$$

где: E - показатель эффективности капиталовложений,
I - капиталовложения в строительство шахты,
q - показатель рентабельности,
n - средневзвешенный период амортизации,

$\sum_{i=1}^{n} K_i$ - сумма эксплуатационных издержек в течение n лет от начала строительства шахты,

$\sum_{i=1}^{n} P_i$ - сумма стоимости горного производства, полученная вследствии строительства шахты в течение n лет в количественном или денежном выражении.

В условии польских угольных шахт принимается $q = 0{,}07$ и $n = 20$ лет. Подсчет ведется отдельно для производственных и сопутствующих капиталовложений. При однородном производстве возможно величину P представлять в тоннах и тогда E обозначает полную удельную себестоимость производства.

Подсчет экономической эффективности создает возможность сравнения целесообразности строительства отдельных шахт, шахт добывающих ископаемые или разные виды того-же ископаемого.

При подсчете непосредственной экономической эффективности строительства горного округа используется эта-же формула с тем, что величины P, K, I обозначают суммы для всех строящихся шахт и в величину I входят сопутствующие капиталовложения по освоению целого горного округа.

В условиях верхнесилезского угольного бассейна капиталовложения на строительство шахты проектной мощностью 2 млн.тонн в год составляют ок. 40 млн.$. При большой газоносности залежи, проходки стволов с замораживанием и углублении обогащения, эта сумма возрастает до 70 млн.$.

При строительстве более крупных шахт удельные капиталовложения снижаются примерно при шахтах мощностью 2,5 млн.тонн в год на 10-15%, а при шахтах мощностью 3 млн.тонн в год на 15-30%. Сопутствующие капиталовложения составляют: 35 до 60% производственных капиталовложений.

Примерная структура в процентах капиталовложений на строительство шахт /по Морозу и Венгерскому/ представляется следующим образом:

по группам		по отраслям	
производственные	66,8	исследования и проекты	3,7
сопутствующие	7,7	горные выработки	25,5
посредственные	25,5	содержание выработок	10,4
		машины и оборудование	20,7
по видам		подготовка промплощади	0,6
исследования и проекты	3,7	производственное строительство	5,5
горные работы	35,9	вспомогательное строительство	1,9
машины и оборудование	20,7	общее строительство	19,8
поверхность	39,7	сообщения	4,5
		энергетика	4,6
		санитарные установки	1,6
		газовые установки	0,2
		с в я з ь	0,9.

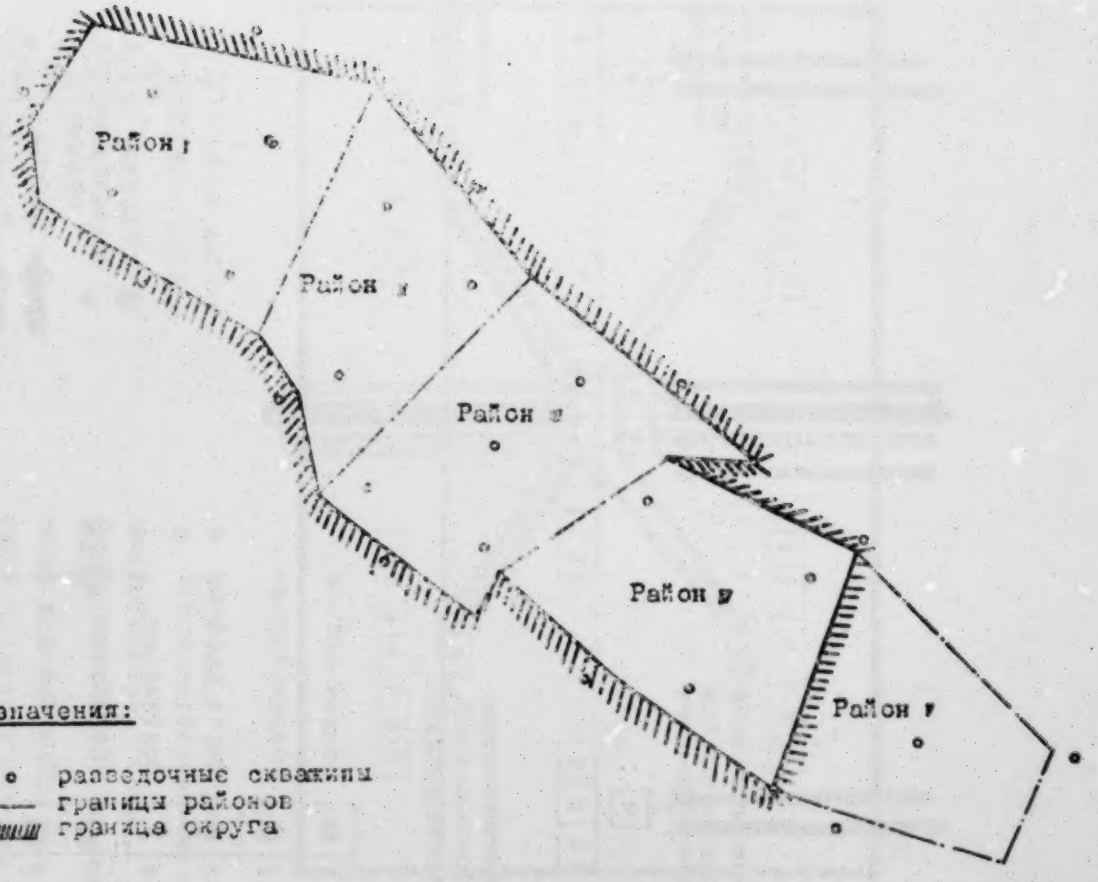
12. <u>Заключение.</u>

Представленные в докладе главные принципы комплексного освоения месторождений, заключающие геологическую, горную, организационную и экономические части, приводят к горному освоению месторождения как цельной единицы и к комплексному подходу к сопутствующему строительству, гарантируя:
- рациональное определение и расположение шахтных полей,
- рациональное проектирование междушахтных сетей сообщения и связи,
- рациональное проектирование поселенческой сети,
- рациональное проектирование сети горных подсобных предприятий,
- рациональную организацию и управление строительством,

приводят в результате к достижению наивысшего общего показателя эффективности капиталовложений.

Комплексный проект освоения месторождения, согласовывающий проектирование как во времени, так и в пространстве, всех содействующих отраслей промышленности в течение целого периода проектных работ и на целой территории приводит к оптимальному планируемому развитию народного хозяйства.

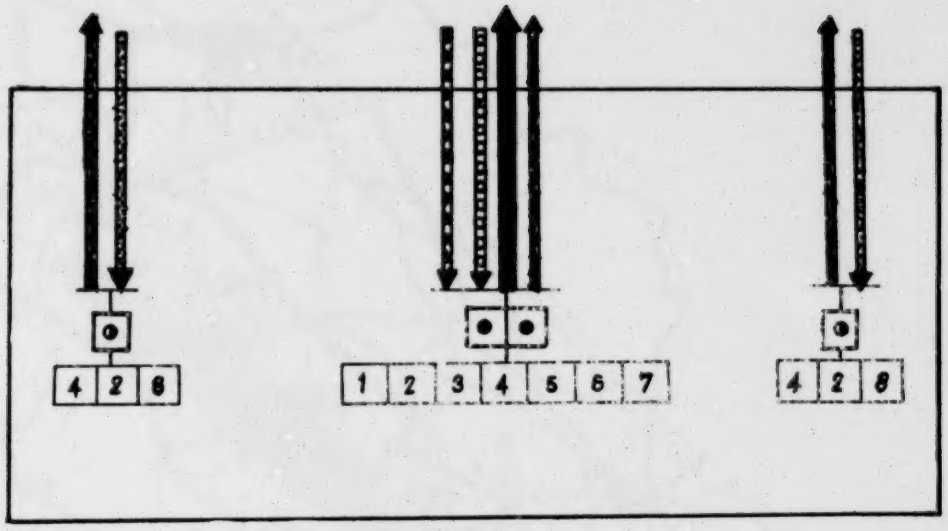
Рисунок №. VII. Пространственное освоение горного округа.



Обозначения:

- разведочные скважины
- границы районов
- граница округа

Рисунок № I. Раздел Округа на районы.



1 Подъем добычи
2 Подъем породы
3 Спуск рабочих
4 Вентиляция
5 Обогащение
6 С к л а д ы
7 Мастерские
8 Закладка

Главные стволы
Вспомогательные стволы
Добыча
Рабочие
Материалы
Порода
Гидрозакладка

Рисунок Ж.II.Схема самостоятельной шахты.

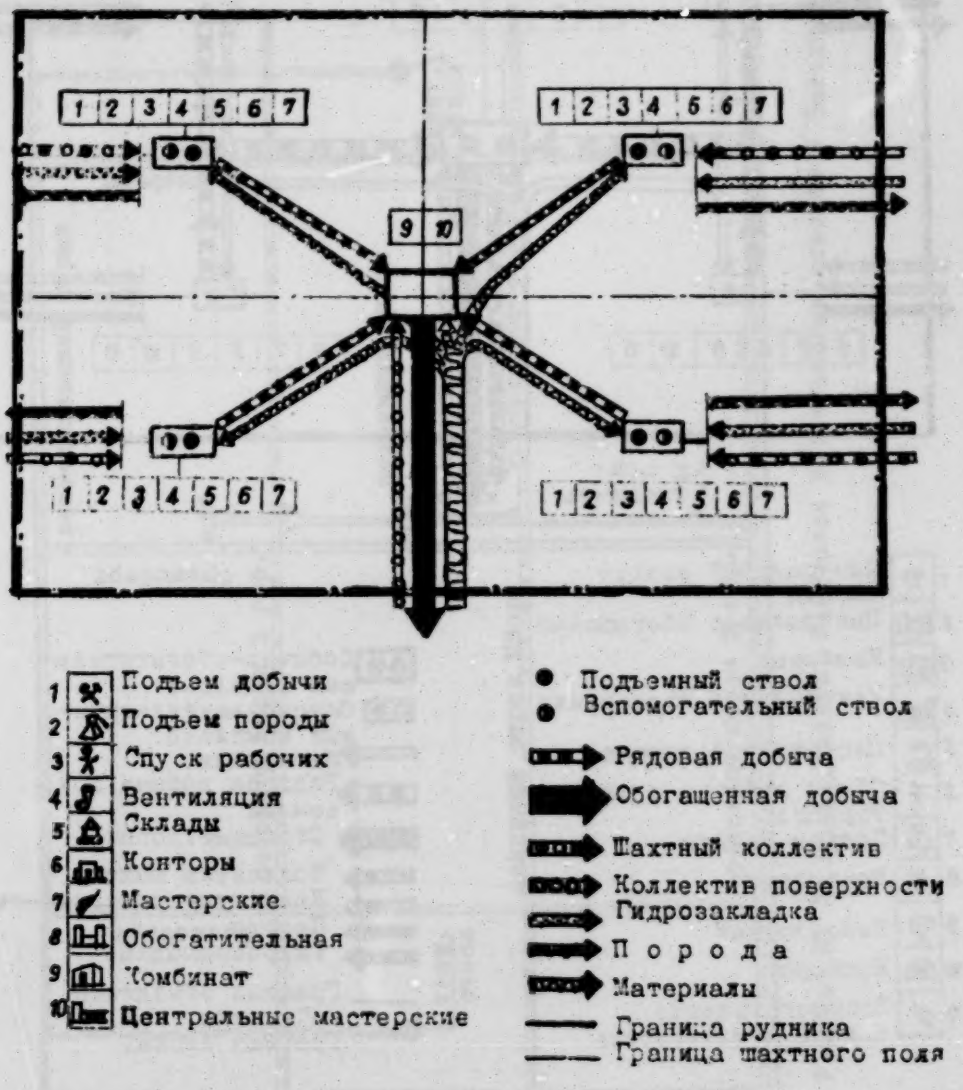
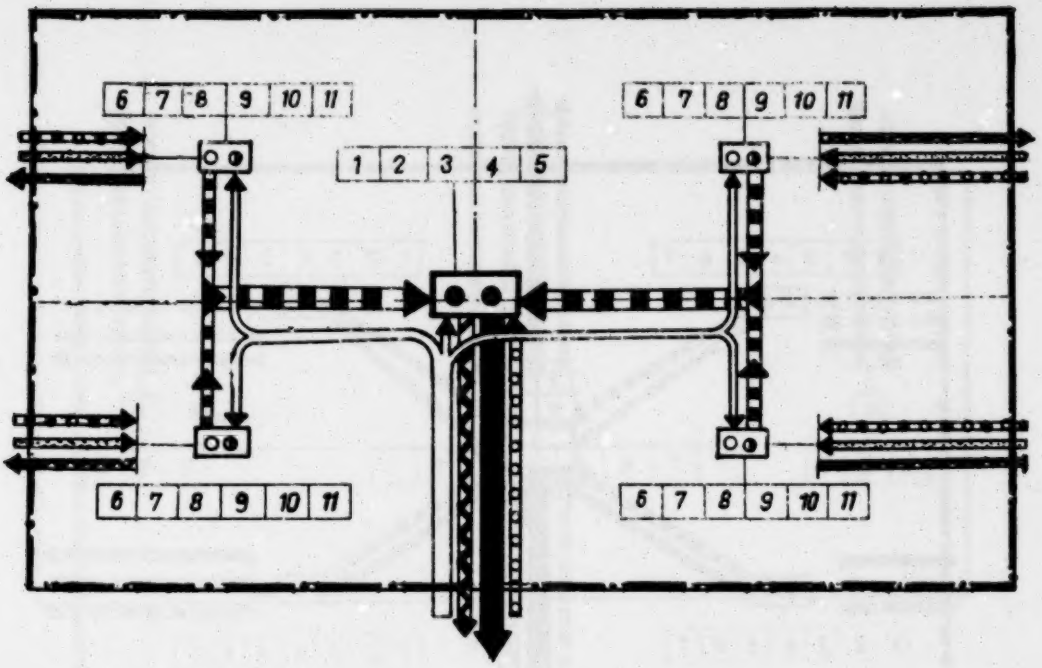


Рисунок Ж. III.Схема групповой шахты.



1 Центральный подъем добычи
2 Центральное обогащение
3 Комбинат
4 Центральные мастерские
5 Центральные склады
6 Спуск рабочих и материалов
7 Подъем породы
8 Вентиляция
9 Закладочная
10 Конторы
11 Вспомогательные склады и мастерские

Добычно-обогатительный комплекс
Спуско-вентиляционный комплекс
Материалы
Рядовая добыча под землей
Обогащен.добыча
Коллектив шахты
Коллектив поверхности
Порода
Гидрозакладка.
Граница объединенной шахты
Граница блока.

Рисунок И. IV. Схема объединенной шахты.

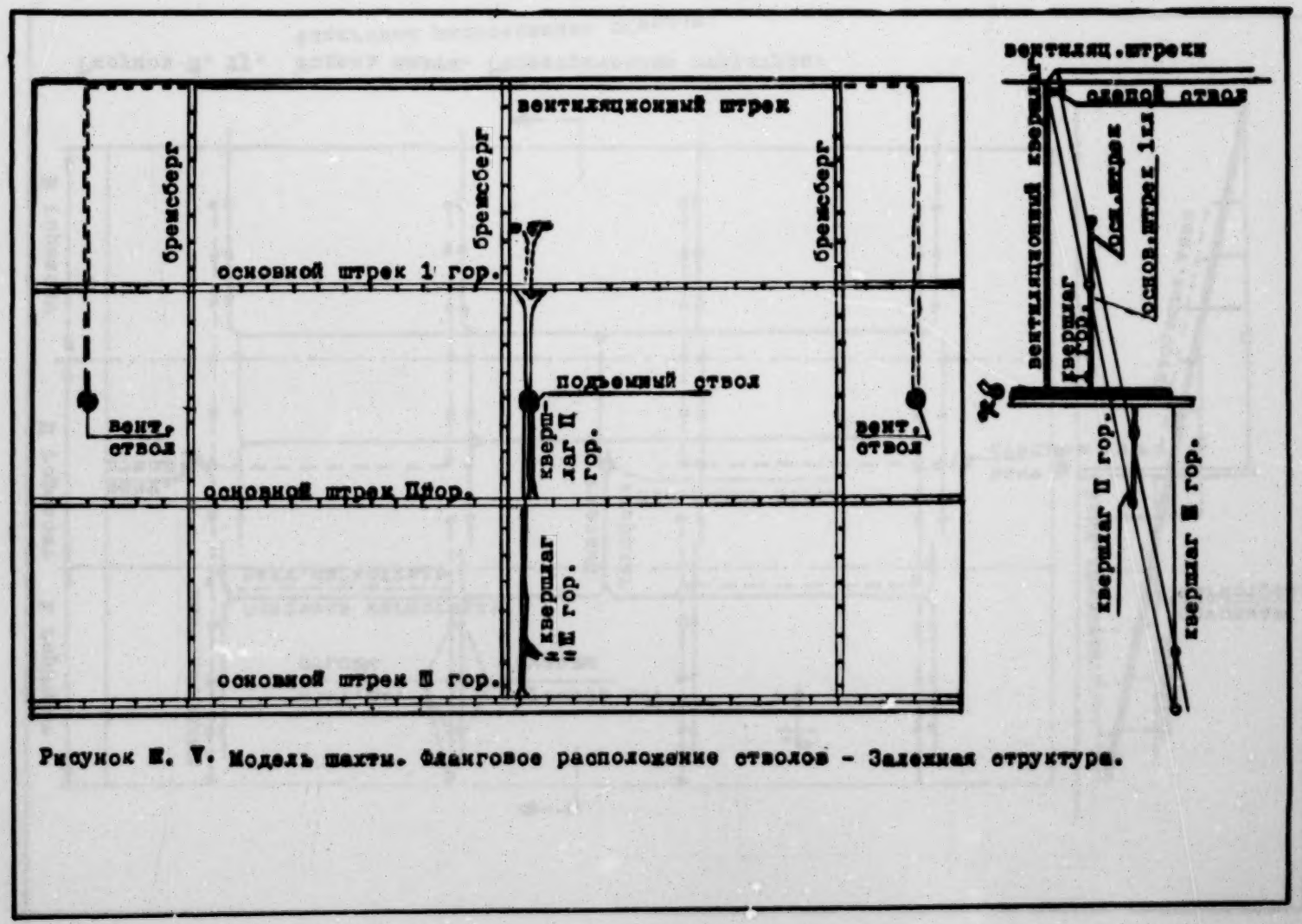
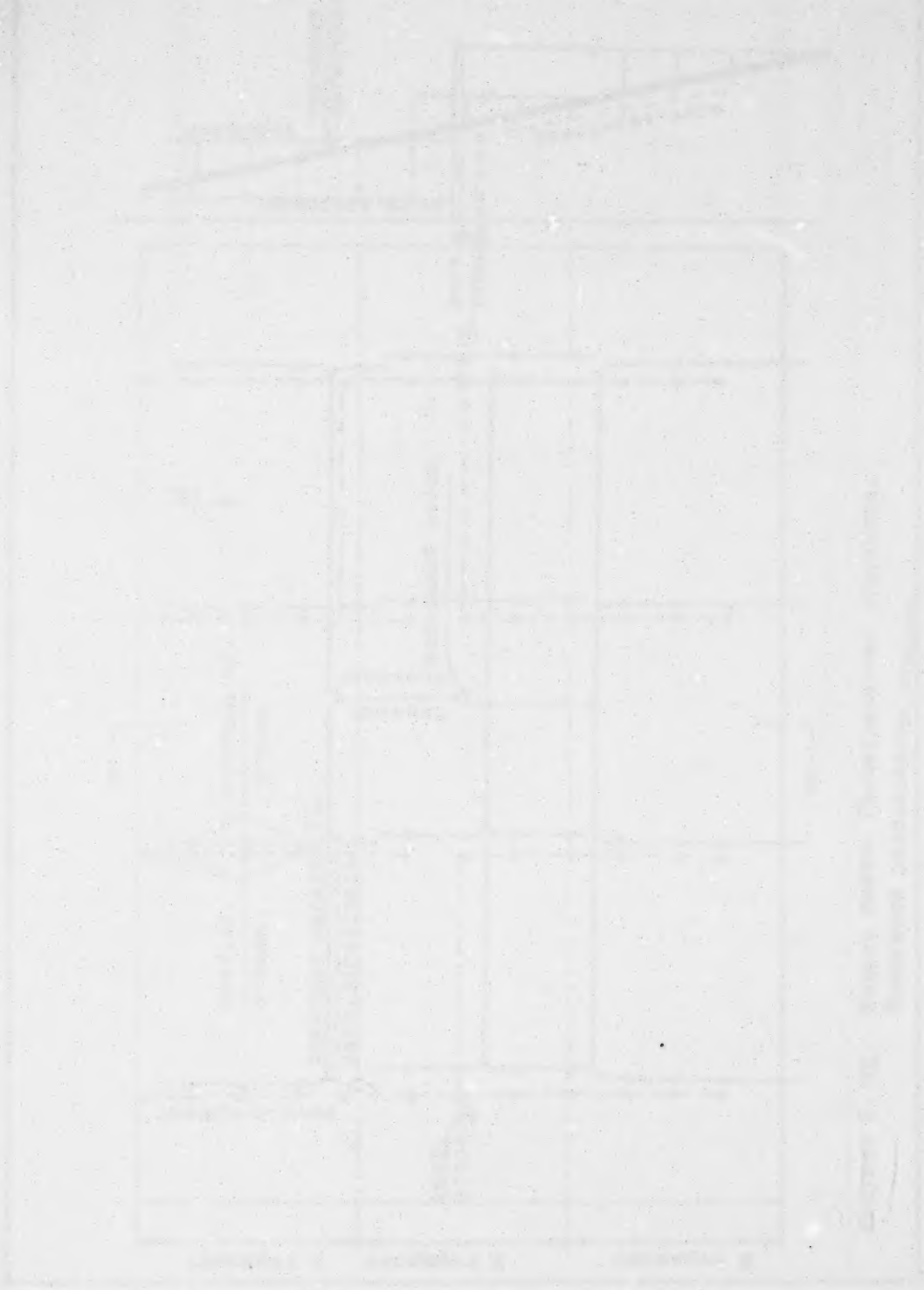


Рисунок II. V. Модель шахты. Фланговое расположение стволов - Залежная структура.

III горизонт
II горизонт
I горизонт
вент. ствол
вент. ствол
вент. ствол



798 R - Nov.1962 - 600

NOTES

1. Les mémoires choisis pour être présentés en séance générale pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

2. Les mémoires choisis pour être présentés en séance spéciale pourront être obtenus à la Conférence dans l'une seulement de ces langues officielles.

3. Les résumés qui ont été rédigés pour tous les mémoires par les auteurs de ceux-ci pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

4. Préalablement à la Conférence, les mémoires et les résumés ne feront pas l'objet d'une distribution générale mais d'un tirage restreint destiné aux délégations des gouvernements et autres participants officiels. La publication et la distribution générale des actes de la Conférence s'effectueront conformément aux règles et pratiques agréées par le Comité des publications des Nations Unies.

A.3.1.1. **BASES D'UNE POLITIQUE DE L'EAU EN ZONE SAHELIENNE**

HYDRAULIQUE PASTORALE

Par le Docteur P. RECEVEUR

C'est un truisme que dire et écrire que l'eau en zone sahélienne est l'élément indispensable qui conditionne toute vie, tant humaine qu'animale et que dans des régions où la saison sèche dure de 7 à 9 mois, souvent plus, la mise à la disposition des populations de cet élement est la base de toute politique saine.

Mais là où les conceptions diffèrent, c'est quand il s'agit de passer à l'exécution des principes, plus particulièrement lorsque, l'eau est profonde et d'atteinte malaisée. C'est alors, qu'à notre avis surgissent les solutions de facilité, dont le seul but semble être de mettre en paix la conscience de leurs auteurs, après un gaspillage de fonds et de moyens qu'aucun des résultats acquis ne justifie.

C'est pourquoi il nous paraît indispensable d'établir une doctrine de base en ce domaine car c'est là le seul moyen d'obtenir les résultats qui s'imposent, en évitant les "erreurs" mentionnées ci-dessus.

A - Le problème - Les données de base.-

Données physiques : Le facteur qui domine tout le problème est le climat. Aussi est-il indispensable de le situer dans ses divers éléments : pluviométrie, température et hygrométrie.

I°) Pluviométrie.- La pluviométrie annuelle dans la zone que nous retenons varie de 100 à 450 mm, la bande 200 - 350 étant celle du maximum d'intérêt.

Les pluies s'étagent de fin Juin à Octobre, avec un maximum de mi-Juillet à début Septembre. Elles ont généralement lieu sous forme d'orages violents et brefs, espacés d'un à plusieurs jours.

2°) Température.- Du point de vue thermique, l'année peut être divisée en quatre périodes :

a) Saison des pluies - fin Juin - fin Septembre.
température relativement basse, degré hygrométrique relativement élevé.

b) Saison intermédiaire - Octobre - mi-Novembre.
Hausse thermique marquée - l'hygrométrie demeurant toujours relativement élevée.

c) Saison froide - Mi-Novembre - mi-Mars.
température relativement basse, hygrométrie faible.

d) Saison chaude - Mi-Mars - Fin Juin.
température très élevée, hygrométrie toujours très faible.

C'est à cette époque que les besoins physiologiques en eau sont maxima, alors que les ressources en cet élément sont les plus réduites.

Ce complexe pluvio-thermique impose au pays un faciès très particulier éliminant pratiquement toute source, toute rivière ou tout point d'eau permanent.

Données humaines et animales: Le climat tel qu'il vient d'être évoqué impose à l'homme une économie spéciale : l'économie pastorale. Toute agriculture se trouve pratiquement éliminée du fait d'une pluviométrie insuffisante qui n'autorise de Juin à Octobre que la pousse d'un pâturage de type très adapté, constitué soit d'espèces herbacées annuelles, soit plus rarement vivaces, parsemées d'arbres de densité allant décroissant du Sud au Nord, en fonction même de la hauteur d'eau annuelle reçue.

C'est ce milieu que l'homme doit exploiter et il ne peut le faire que par l'intermédiaire du bétail.

Si celui-ci trouve dans cette zône son aire d'extension optimum, puisque non concurrencé par quelque autre activité que ce soit, il n'en demeure pas moins qu'il y est soumis à des règles très strictes, imposées à la fois par les besoins alimentaires et la pathologie, et auxquelles doit impérativement se plier l'éleveur, sous peine d'échec total.

Il doit assurer à son bétail:

a) un pâturage suffisant, fonction de la nature du terrain et de l'abondance des pluies annuelles.

b) un abreuvement minimum, lui-même fonction soit des pluies (eaux de surface ou à faible profondeur), soit des nappes phréatiques qu'il peut atteindre et exploiter.

Si ces multiples impératifs s'interpénètrent, l'un d'eux :l'abreuvement, est durant au moins huit mois de l'année, de Novembre à Juillet, un facteur absolu, régissant tous les autres, comme l'illustre parfaitement la réponse que nous fit un jour un vieil éleveur, à la remarque que nous lui faisions sur le rassemblement de nombreux troupeaux sur un point d'eau autour duquel il ne substituait pas la moindre trace de pâturage plusieurs kilometres à la ronde :" de soif on meurt en trois jours, de faim en un mois !". Et nous n'avons d'ailleurs pu que nous ranger à cette vérité, qui conditionne trop souvent au sahel l'existance même des gens!

Ce qui explique pour ces éleveurs purs, et qui ne peuvent pas être remplacés par quelque chose autre que ce soit, l'obligation d'être en perpétuelle errance sur des parcours suffisamment vastes, qu'ils doivent exploiter en tenant compte de tous les considérants ci-dessus indiqués, variables selon l'année, dans des conditions auxquelles, avec les seuls moyens dont ils disposent, ils ne peuvent échapper.

Que peut-on faire pour eux, quel programme envisager pour rompre ce cycle ?

Une seule réponse est possible : leur donner l'eau.

B - La solution : l'eau

Examinons d'abord quels sont les besoins et la manière dans les conditions actuelles dont ils sont satisfaits.

I°) Les besoins.- Ces besoins en eux-mêmes absolus varient avec l'espèce et, pour une même espèce, avec l'individu pour qui ils sont fonction de l'époque de l'année envisagée, Mars à Juillet étant l'époque où ils sont les plus élevés. On estime qu'il est alors nécessaire de disposer des quantités suivantes :

Bovins	40 à 50 Litres
Chevaux	30 à 40 Litres
Ovins - caprins	5 Litres
Chameaux	40 à 50 Litres, le tout journellement

2°) Comment ces besoins sont-ils satisfaits ?

De manière quasi générale, on peut dire que les besoins ne sont satisfaits que pendant les 4 mois d'hivernage, grâce aux mares résultant des pluies, et que la carence en eau augmente au fur et à mesure que l'on s'en éloigne alors que, inversement, les besoins de l'individu en eau de boisson s'accroissent.

A partir de la fin de la saison des pluies tout se déroule selon le schéma suivant :

I°) A la fin Octobre les animaux, dispersés sur les pâturages, commencent à se regrouper autour des mares, en débutant par celles qui s'assèchent le plus vite de façon à pouvoir profiter au maximum des ressources en fourrage.

2°) Fin Novembre généralement, le regroupement est terminé autour des collections superficielles qui subsistent jusqu'à fin Décembre, Janvier.

3°) A partir de cette date on note :

a) ou le creusement de puisards dans les fonds de mares asséchées, afin de bénéficier de l'eau de retenue souterraine;

b) ou une descente vers le Sud, sur les mares quasi pérennes;

c) ou une occupation des puits à faible profondeur.

4°) A partir de Mars, regroupement :

a) sur les mares pérennes, b) sur celles qui, asséchées, possèdent des réserves souterraines en eau suffisante permettant le creusement de nombreux puisards, c) sur les puits profonds.

Sont également exploités à cette époque, des puisards à très faible production, dispersés un peu partout, sur lesquels ne s'entretiennent que quelques sujets.

De manière générale à cette époque de l'année l'abreuvement du cheptel est très déficitaire. Les animaux ne reçoivent pour la plupart que tout juste la quantité d'eau qui les empêche de mourir, buvant au mieux une fois tous les 2 jours. Inutile de dire que cette situation est particulièrement grave pour les jeunes qui ont à la fois le plus de besoins et la résistance la plus faible, alors que bien souvent ils sont évincés de l'abreuvoir par les plus forts.

C'est une des causes qui expliquent pourquoi un quart seulement des jeunes parvient à lâge adulte, qu'ils atteindront souvent après que leur organisme aura été définitivement marqué par les privations qu'ils ont subi, au grand dam de leur productivité ultérieure.

La raison qui explique ce sous abreuvement est simple : l'eau manque.

Pourquoi ?

Soit parce qu'elle n'existe dans le sol qu'en quantité trop faible (cas de l'exploitation par puisard des eaux souterraines résiduaires),

soit parce que, lors de nappes profondes importantes, elles ne peut être extraite qu'en quantité insuffisante.

Il ne faut pas oublier - ce qui est souvent le cas - que la seule eau qui compte ce n'est pas celle qui est au fonds du puits, mais celle qui en est extraite et mise à la disposition du bétail.

Or, sur un puits profond à grand diamètre - et les puits du Niger sont en majorité compris entre 40 à 70 mètres - il est quasi impossible avec les moyens coutumiers dont disposent les éleveurs de sortir plus d'un tiers de litre par seconde, soit I.200 litres/Heures - ce qui correspond à l'abreuvement théorique de 24 à 30 boeufs, si leurs besoins doivent être satisfaits pleinement, et celà au prix d'un véritable travail de forçat.

Dans de telles conditions il est bien certain, qu'on le veuille ou non, qu'il est impossible d'entretenir correctement les centaines de milliers de têtes de bétail qui paturent à cette époque en zône sahélienne.

3°) Le Remède.-

Le remède, et le seul, consiste à donner l'eau en quantité suffisante. De nombreux efforts ont été effectués dans ce domaine, beaucoup d'entre eux n'ayant malheureusement donné que des résultats dérisoires, et celà du fait que la seule eau qui compte est, comme nous le disions plus haut, celle qui est à la surface du sol. Or le creusement de puits trop profonds, non associé à une politique d'exhaure, ne résoud rien, l'homme étant alors impuissant à sortir les quantités nécessaires à son bétail. Une politique d'exhaure s'impose pour modifier les conditions d'abreuvement qui sans celà demeurent.

Mettre impérativement à la disposition du bétail la quantité d'eau dont il a besoin, condition sine qua non de son existence, étant l'objectif indiscutable, comment y répondre ?

Deux solutions sont possibles, fonction de la profondeur de l'eau.

I°) Eau superficielle ou relativement superficielle (moins de 30 mètres de profondeur). Puits à grand diamètre, le puisage se faisant manuellement ou à l'aide de l'animal. Le débit ne doit pas être inférieur à ½ et mieux à 3/4 litre seconde, correspondant à la quantité d'eau que peuvent extraire les éleveurs par leurs procédés coutumiers, qui peuvent ici être retenus, ces points d'eau ne devant abreuver qu'un nombre de têtes réduit ne dépassant pas 5 à 600.

Cette solution à l'avantage d'éviter les gros rassemblements de troupeaux, mais par contre, sur le plan social, elle a un inconvénient certain : celui de disperser une population qu'il y aurait avantage à regrouper.

2°) Eau profonde : (plus de 30 mètres) la seule formule est la station d'abreuvement.

Par ce terme nous désignons tout forage ou puits profond équipé des moyens d'exhaure nécessaires, avec système de stockage et de distribution de l'eau extraite. C'est à notre avis la seule solution possible pour la mise en valeur du sahel chaque fois qu'il est impossible d'obtenir une eau superficielle, telle que définie précédemment. C'est le cas le plus général au Niger.

Une telle station comporte :

I°) un forage à débit minimum de 4 litres seconde, supérieur si possible,

2°) un dispositif d'exhaure mécanique (pompes verticales mues par moteur, généralement thermique, d'un débit correspondant à celui du forage

3°) un dispositif de stockage d'eau de sécurité (cuve, réservoir),
4°) un dispositif de distribution de l'eau, canalisations et abreuvoirs.

Le coût d'un tel dispositif, variable selon les conditions d'exécution, est généralement élevé. Aussi importe t-il, pour l'économie de l'opération, qu'il abreuve un nombre suffisant d'animaux.

Selon les calculs auxquels nous nous sommes livrés et que nous communiquerons bien volontiers, il faut abreuver 3.500 à 4.000 unités bétail, l'unité type étant le boeuf, la correspondance admise entre les espèces étant un boeuf = I chameau = 8 moutons ou chèvres. Le coût de fonctionnement de l'opération doit être à la charge des intéressés, qui peuvent facilement le supporter, l'accroissement de rentabilité de leur troupeau le leur permettant sans difficulté aucune.

Plusieurs objections ont été adressées à ce système dont la principale est celle de la surcharge du pâturage qui ne manquera pas de se produire amenant sa destruction. Il est certain que, si aucune règle d'exploitation des pâturages n'est appliquée, c'est là un écueil certain pour le maintien en condition des animaux.

Mais il est aisé d'y remédier.

Si l'on admet que l'exploitation du pâturage peut se faire jusqu'à IO Kms du point d'eau (ce que l'expérience confirme : optimum d'exploitation : rayon de 4 à 5 Kms, maximum d'exploitation : rayon de 9 à IO Kms : nous l'avons souvent vérifié par l'examen kilométrique du % de consommation de pâturage autour du point d'eau), c'est donc une superficie de 30.000 ha environ qui est disponible. En admettant le taux moyen de 7 ha par boeuf, c'est dont 4.000 animaux qui, pendant un an, peuvent s'y entretenir. Si de plus on tient compte qu'un pâturage peut être exploité indépendamment par diverses espèces, les matières alimentaires appétées par les unes étant négligées par les autres (cas de l'association sur un même pâturage de bovins, moutons, caprins, chameaux) on voit qu'il n'y a guère de risques de surcharge, tant que le total ne dépasse pas 6 à 7.000 unités diverses.

Si l'on effectue le même calcul pour le rayon d'entretien optimum (qui donne une superficie de 7.500 à 8.000 ha) on voit que dans ces conditions c'est une charge annuelle de I.000 à I.200 unités bovins, auquel s'ajoute environ autant d'unités bétail autres, soit un total d'environ 2.500 unités bétail diverses qui peuvent être entretenues et ceci, sur un cycle annuel. Si l'on note que souvent 5 ha par animal suffisent on est amené à 3.000 unités bétail, chiffre voisin des 3.500 à 4.000 retenus.

Mais dans les faits il n'y a pas lieu d'admettre l'exploitation annuelle totale, celle-ci étant interrompue pendant au moins les mois d'hivernage. C'est donc en réalité, pendant 7 à 8 mois que l'utilisation se fait, ce qui ramène à $\frac{75}{I2}$ soit environ 3 ha, la superficie nécessaire par animal, soit une possibilité de 3.500 U. bovins, ou 7000 U. bétail de toutes espèces qu'il est possible d'entretenir.

Et ce ceci, comme nous le soulignons plus haut, dans les conditions optima d'entretien alimentaire. Dans la pratique la réalité se situe entre l'optimum et la limite possible. Si nous retenons alors un rayon de 7 kms,5, nous voyons que la charge annuelle en bovins peut être d'environ 3.000 U. bovins (pour une superficie voisine de 2I.000 ha) soit 6.000 U. bétail divers au total, charge qui passerait à 5.000 unités bovins ou I0.000 unités divers si nous calculons, comme il est normal, sur une durée d'utilisation de 7 mois.

Notons enfin que pour codifier ces charges et durée d'occupation, des textes règlementaires se doivent d'être pris pour, en particulier, préciser taux de charge, durée d'occupation d'une part, lutte contre les feux de brousse préventivement et curativement d'autre part ceci afin de prévenir les abus et éviter les destructions inconsidérées.

Il est bien évident qu'une station de pompage en elle même n'est qu'un élément d'un plan d'ensemble et que seule elle ne saurait résoudre tout le problème, le plan général consistant à équiper l'ensemble du sahel d'un réseau de puits et de station de pompage associés d'une manière telle qu'ils permettent l'utilisation raisonnée de la totalité des

ressources fourragères de la zône envisagée - ressources qui, nous insistons, sont les seules auxquelles on puisse songer pour assurer le développement économique de cette zone.

Le plan théorique d'exécution d'un tel programme devrait -dans l'absolu - comporter :

I°) Détermination exacte des régions à vocation pastorale stricte ou à large dominance pastorale.

2°) Détermination, dans les régions ci-dessus précisées :

a) de la répartition des pâturages (types, superficie, charges à l'hectare prévisibles).

b) des ressources en eau existantes et des possibilités de leur exploitation (eau superficielle ou souterraine).

c) de la répartition actuelle de l'Elevage ; groupements humains utilisateurs, importance du cheptel, parcours coutumiers.

Muni de ces renseignements il devient alors aisé de porter sur la carte l'emplacement des puits et forages profonds reconnus nécessaires, les ouvrages commandant un rayon de 3 à 5 kms pour un puits, 7 à I0 kms pour un forage, ceux-ci étant répartis en fonction :

a) de l'importance du cheptel en liaison avec les groupements humains qui les détiennent,

b) du mode de forage adopté, puits ou forage profonds, en respect de l'impératif économique : rapport du coût au nombre de bénéficiaires, ce qui conduit à préconiser la solution théorique suivante : (nous insistons sur le mot théorique).

Puits - Tous les 7 à I0 kms en tous sens

Forages profonds - Tous les 20 kms

En fait, une telle répartition doit obligatoirement tenir compte des correctifs suivants :

a) mares d'hivernage, durée d'utilisation de celles-ci.

b) nécessité de concentrer le maximum de têtes sur un point donné (en fonction de la quantité d'eau réellement disponible par tête) pendant la période de fonctionnement tout particulièrement lorsque des moyens d'exhaure mécaniques sont utilisés., la période d'utilisation prévue portant sur I50 à 200 jours, étant évident qu cela est, comme nous l'avons souligné, théorique et que sur le plan pratique des correctifs s'imposent en fonction des conditionnants locaux.

Il est par ailleurs bien certain qu'un tel plan, pour en obtenir tous les résultats désirables, doit être précédé d'une étude sérieuse portant en particulier la valeur, l'occupation et l'utilisation coutumière des parcours à aménager - ceci afin d'éviter des erreurs à la fois sur les plans économiques et sociaux.

Ceci reconnu, il aura lieu une fois décidé de l'exécution du programme de le sanctionner légalement par les textes indispensables, lois, décrets, textes d'application, codifiant ainsi le mode de vie sociale et économique nouveau, qui, logiquement, en découlera, se faisant sentir à la fois sur les domaines sociaux : attribution de stations et des pâturages correspondants à des tribus ou groupes ethniques en fonction de la politique du Gouvernement en ce domaine influant sur l'Enseignement et la santé, et économiques : économie de marché se substituant à l'économie de troc, tout celà conséquence de la sédentarisation et du regroupement temporaire provoqués par l'existence du point d'eau.

Tout ce que nous venons d'exposer n'est pas, comme peut-être certains pourraient le penser, une simple construction théorique. Les travaux entrepris en ce domaine dans la zone sahélienne du Niger, au Nord de Tahoua à l'intérieur d'une quadrilatère d'environ 250 Kms Nord-Sud et I80 Kms Est-Ouest ont conduit à la mise en service de I5 Stations, qui toutes fonctionneront au cours de la saison sèche I962-I963.

Les résultats acquis à ce jour démontrent totalement le bien fondé de la politique ci-dessus exposée, une transformation profonde du mode de vie dans cette région se faisant jour, transformation pleinement appréciée par les populations qui y sont intéressées, ceux qui ne sont pas encore bénéficiaires insistant pour rapidement être pourvues elles aussi d'installations identiques.

938 F - Oct.1962 - 1,000

NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

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SOME PRINCIPLES AND EXPERIENCE CONCERNING UTILIZATION OF WATER RESOURCES IN CZECHOSLOVAKIA

by

Jan Smetana, Member of the Czechoslovak Academy of Sciences, Director of The Institute of Hydrodynamics

a) The Increased Demand for Continental Water and the Gradual Deterioration of its Quality.

With to the growth of population, the standard of living and economic development in all advanced countries, the demand for water and its actual consumption are continuously increasing. At the same time, the present rate of water contamination hinders the further development of these countries to a great extent.

A planned and controlled conservancy of the water supply, which is one of the essential natural resources, is therefore of utmost importance.

It has become essential to speed up the percolation of atmospheric precipitation into the ground, to recharge the ground water storage and to reduce losses by evaporation.

Impounding reservoirs not only ensure regular draining but also provide water during low-flow periods.

Another requirement is to keep the quality of the water within acceptable limits.

b) Rational Water Conservancy Requires International Cooperation

Any interference with the flow or the quality of water in an ups ream country affects conditions in all down-stream countries.

International cooperation in the explo tation of water re ources has therefore becom a necessity. The Danube, for instance, is of vital importance to 8 countries.

Such international cooperation is also necessary in complex scientific research. The prevailing local solutions have to give way to wo d-wide schemes in the field of observations and research,

i.e. in ionosphere for long-range weather forecast or in hydraulics, hydraulics, hydrology, hydro-engineering, hydro-geology, hydro-pedology, hydro-biology and hydro-chemistry.

c) Brief Survey of Hydro-Geography of Czechoslovakia.

Czechoslovak streams are drained by the Elbe into the North Sea, by the Odra and Visla into the Baltic and by the Danube into the Black Sea. Connection between the Baltic and the Mediterranean Sea could be shortened by the projected Danube-Odra Canal.

Atmospheric precipitations vary widely, in accordance with altitudes and temperatures within a range of from less than 400 mm to 1,600 mm annually and yield about 93 milliards of cubic metres a year. Almost one third of the country is densely forested. The flood rates are very high and natural flow (not including the Danube) varies between 14 milliard c.m. and 28 milliard c.m. The annual per capita rate of available water is thus only 2,050 c.m.

Flood records of the Vltava River have been kept since the 12th Century, complex hydro-graphic service dates back to 1874 and hydrological research was also established early.

d) Vasic Scheme for Planned Water Conservancy in Czechoslovakia

Since 1945 all natural resources of the country are the property of the State. In view of the fact that economic utilisation of water resources is particularly important for the development of the entire national economy, a " General Plan of Water Conservancy" elaborated on the initiative of the Government and passed in 1953, provides for the efficient utilisation of water in the interests of the entire national economy.

The plan is based on a reliable estimate of the ground water storage and the possibility of its accumulation as well as the utilisation of surface waters. It determines the requirements for its quantity and quality, its location and time according to the actual demands of the different branches of industry; the perspective demands of all other fields have also been taken into considération. The possibilities have been incorporated into the final balance of water conservancy with the view to putting the actual future provisions of the plan into conformity with all

demands of the economic development of the country. The plan is flexible enough to provide for adaptation to possible variations and can be supplemented, enlarged, and improved. It was the first of its kind.

For periods of drought, measures for accumulating water have been considered to keep the flow rate regulated above a certain limit. According to this provision the quality thus attained is to meet at least category III of the Czechoslovak standard.

This plan, which is authorised by the Government, thus incorporates the principles for an efficient exploitation of water and a new bill on the utilisation of water resources. It ensures that the demands of water for all branches of the economy are met in time.

e) Augmentation of Water Supply by Storage

Czechoslovakia has an ingenious system of large fish-ponds, which were built between the 13th and 16th Centuries; the Builders of such ponds were also in great esteem and demand in the neighbouring countries of the then independent Czech state. The influence of these ponds is felt even today in the effective lowering of the peak-flow run-off from the respective drainage regions.

Special care is now devoted to the construction of big "key reservoirs. In regions with unfavourable hydrological, orographical or geological conditions re-pumping of the run-water is planned to more advantageous sites. On the Vltava River there is a system of dams and reservoirs with weirs, on the Elbe River a cascade of weirs and canals, and on the Váh River, a system of weirs and accumulation reservoirs.

By 1945,a total reservoir capacity of 0.25 milliard c.m. was completed, by 1960 almost 1.4 milliard cu. m. and the planned capacity for 1965 is 2.6 milliard cu.m. According to the state plan for water conservancy, a total of about 10 milliard cu.m. of stored water will be available after the final completion of all possible and economically useful reservoirs.

f) Canalization of Rivers for Navigation Purposes, the Use of River Canalization as Source of Water Supply. Further Advantages of Canalization.

An effective system of inland waterways is of great importance

for international trade. The depth necessary for safe navigation is ensured in Czechoslovakia by effective canalization, specially on the Vltava and Elbe Rivers, with a system of weirs, dams and navigation chambers, which make the disadvantageous discharge of valuable supplies of water from reservoirs unnecessary. Canalization on the Elbe affords passage for ships down the river to Hamburg. On the territory of the GDR, however, canalization of the Elbe has not yet been accomplished.

The building of large dams, especially on the canyon-like stretch of the Vltava above Prague, which is controlled and fed by large reservoirs on the upstream tract, has become an important source of power. A system of waterways and elevators for big ships and big heads is being developed. Thus big reservoir capacities and heads are gained while only a minimum quantity of water is required for navigation. Under favourable conditions these reservoirs are also of great importance for the quality of the water.

g) Hydro-power in Czechoslovakia Serves mainly to Cover Peak-loads.

The available amount of water power in Czechoslovakia is limited by its comparatively small and low-flowing streams. The ultimate attainable goal is the utilization of about 10 milliard kWh. annually. This basic load in the diagram is covered mainly by thermal power stations, and hydro power plants, especially at big reservoirs, serve mainly to cover peak-loads. Great achievements were made especially in the construction of Kaplan turbines with swivelling blades (Kaplan was a professor at the Technical College of Brno where he invented and developed this type of turbine). Their main advantage is not only their large capacity but the great head achieved in our country without danger of cavitation (aggregates of a capacity of 150 cu.m. per second, a head of 71 m. and an effectiveness of 92 %).

h) Progressive Methods of River Regulation.

Regulation of big rivers was formerly undertaken according to their number and especially during the vegetative period to protect the valleys and farmland. The result was usually that the ground water level was reduced in dry periods and the earth dried out. Meanders in the past were too radically straightened out by canals

which caused a rapid and disadvantageous run off and the flow-rate increased so much that it adversely affected the stability of the river-bed.

Today we try to limit floods if possible by accumulation in protection reservoirs while keeping river-beds relatively shallow, which prevents too great a drop in the water level in a dry period, and supports the possibility of natural water purification. If the protection reservoirs fail to check floods, low levees are built along the river banks.

In developing Potapovś method (USSR) of using flow guides to protect the banks and to form a river-bed with hydraulic equilibrium, we elaborated this method theoretically and applied it in our country.

i) Major Problems Concerning the Quality of Water.

In addition to providing the necessary quantity, the second biggest problem of Czechoslovak water conservancy is the purity of the water.

Half a milliard crowns are invested annually by the Czechoslovak government in the construction of about 100 treatment stations for discharge waters.

Despite the continued general deterioration of the quality of water, a considerable improvement can be observed locally, where the effect of completed water treatment stations, of which there are over 600, is felt.

This is why we endeavour to introduce such progressive technological methods in industry in which a minimum amount of discharge water is produced, to speed up research in biology, chemistry and sanitary engineering to make the discharge waters innocuous, and new radical charges in technology in discharge water treatment.

Examples of some successes achieved here :

Production process in sugar mills limiting discharge waters to a minimum; application of these methods in other sugar mills resulted in the fact that no impairment to the quality of the water leaving Czechoslovakia could be detected during the sugar-processing season. Elsewhere the content of phenols was reduced by 50 % without construction of special installations. Joint biological and sanitary engineering research reduced the proportion of sulphates in discharge waters in the production of citric acid by more than 80 % when methanic fermentation was used. Innocuity of discharge waters in industry is becoming increasingly a question

of economy. We also deal with eliminating radioactivity of water, removal of detergents and water from sulphite cellulose, from synthetic rubber production, etc.

We do not under-estimate the natural clarification process in rivers and support it in river regulation by air-blowing at falls, from the view point of distributing the temperature, etc.

For improving discharge water we use ashes and slag, great quantities of which are produced in Czechoslovakia.

In hydraulic slag conveyance discharge water can be absorbed and phenols and other substances detained.

With the water shortage, future plans must envisage re-circulation which even today can be sixfold.

j) Impounding Reservoirs as Source for Domestic and Public Supply

If we do not want to dry out the land by draining off ground water, we must use and treat surface water. We carry on research of water in reservoirs so that oligotrophy may be maintained as long as possible.

Complex dynamic, physical, biological and chemical processes take place in water reservoirs. A study of the occurrence of substances in water entering and leaving the reservoirs has shown that the content of some substances in the water is greatly reduced while it is in the reservoir.

The influence of phosphorus from fertilizers on the formation of water plants has been confirmed. The effect of nuclear test explosions was ascertained by the precipitation of radioactive particles on the reservoir surface which was reduced by one-sixth over the same month last year when nuclear tests where stopped.

For irrigation purposes properly equipped intakes should withdraw water from the warm upper strata. For industrial purposes, especially for cooling purposes, cool water from the bottom without withdrawing the warmer strata should be used. The depth of the water layer which comes into play will be used according to the amount of water drained, so that the density of currents is used only in deep and large reservoirs.

k) Modern Methods of Water Treatment.

Research in Czechoslovakia is directed specially on treatment of drinking water from reservoirs and rivers with a view to coagula-

tion, separation and suspension in fixed and fluidized filtering beds and filtration of treated water. Hydrodynamics of fluidized filtering beds the mechanism of adhesion in porous mediums, theory of coagulation were clarified.

On the basis of this research methods and installations for water treatment in a two-stage process were worked out: " Sludge Blanket Clarifier" (ČSAS - patent) which is based on a fluidized bed filter followed on by high-rate filtration. The equipment can be constructed as a so-called "Packaged Water Treatment Plant", which can be easily transported. It comes in different unit sizes of a capacity of ? to 100 litres per second for medium and very contaminated surface water, or for ground water with a high content of Fe and Mn. A mobile water-treatment plant with a capacity of 6 cu.m. per hour has been developed which suppl fresh and innocuous water in remote and poorly accessible areas and is equipped with its own self-supplying generator. It is very effective in treatment of highly concentrated bacterial pollution and any other substances if in suspension (not dissolved substances).

This equipment is suitable for providing innocuous water in the under-developed countries, where innocuous water treated from local surface water is a condition for the country's development. The equipment proved to be expedient even in difficult sub-tropic conditions.

We would like to recommend to the United Nations Council for Aid to the Under-developed Countries, and the World Health Council, that an expedition be sent to the sub-tropic or tropic zone, where the demand for fresh, innocuous water appears to be most pressing, to test the usefulness and suitability of the equipment. The expedition would also investigate special problems of sanitary significance in combating water-borne epidemic diseases.

1) Conclusion

In order to ensure now and in the future and adequate amount of fresh water for the steadily growing population and for the development of agriculture and industry, rational water conservancy should be introduced, complex development of questions related to water conservancy on an international scale and with international cooperation, international cooperation in the development of those aspects on which the development of rational water conservancy depends, measures on an international scale for the accumulation of

water specially by building big reservoirs at the most advantageous sites on international rivers, transfer of water from rivers abundant in water to rivers whose water does not suffice for the basic requirements, biological, chemical, sanitary and health research with a view to problems of purity of water.

954 E - Oct.1962 - 1,600

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No. 4044 A.3.2.

SOME POSSIBLE APPLICATIONS OF ISOTOPIC ANALYSES OF WATER TO HYDROLOGIC PROBLEMS

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The study of the water geochemical cycle by isotopic techniques began about thirty years ago, with determinations of the specific gravity of the water. This method was subject to great errors and the results were often unexplainable. However, it was possible to derive the idea that some systematic isotopic fractionations result from the processes related to the meteoric water cycle.

The importance of this idea is evident: isotopic fractionation makes it possible to recognize different steps in the water cycle, each step being traced by the deuterium and O^{18} contents of the corresponding water.

These studies greatly progressed only after 1946, with the construction of very sensitive mass-spectrometers, and it became possible to verify and develop some hypotheses proposed by authors such as Gilfillan, Brodsky, Neumann during the years from 1933 to 1940.

The studies of Kirshenbaum, Epstein, Dansgaard, Friedman, Craig etc. give the basis of the interpretation of isotopic variations in water samples which is now qualitatively satisfactory although quantitatively not yet very precise.

In a very simple and general model different isotopic compositions of precipitations are related with the temperature gradients in the air according to Rayleigh's distillation theory.

The average year-round isotopic composition of precipitation is related with the average temperature of formations of the rains: as a consequence latitude and altitude effects on isotopic composition of rains can be expected.

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A decreasing content of heavy isotopes is usually observed with increasing altitude or latitude. From the data recently reviewed by Dansgaard (1) variations of 0,6 - 0,9‰ in O^{18} content of rains per °C, are apparent: this corresponds to a variation of about 0,5‰ per 100 m (cf. 0,6‰ per 100 m found in North Greenland (2)).

The isotherm pattern greatly affects latitude gradients in different regions: so that a general value for this gradient is meaningless.

Seasonal isotopic variations in the precipitations over a region are also a consequence of the dependence of the isotopic composition upon the temperature, as Riesenfeld and Chang first observed. The summer precipitations are enriched in heavy isotopes with respect to the winter ones. This effect is larger in polar or continental regions (difference of about 10-15‰ in the O^{18} content) than in regions with oceanic or maritime climate (about 5-10‰).

The above summarized model can be used in spite of the fact that the isotopic composition of precipitation is also influenced by some factors which are difficult to evaluate such as contributions from evaporations of fresh waters, or precedent history of the vapour masses which condense to produce rains. Moreover the fractionation factor between the vapour and the condensed phases is uncertain in natural processes, chiefly owing to deviations from the equilibrium conditions. A liquid-vapour equilibrium seems to be established for atmospheric precipitation, while the process of free evaporation in nature is probably governed by kinetic factors (3).

The isotopic content in meteoric waters can be considered as a natural tracer allowing application to some geophysical problems particularly in regions with rather simple meteorologic situations.

This is the case in polar regions where isotopic methods have been applied to recognize the provenance of ice in icebergs (1) or the glaciers (4) and to detect a stratigraphy based on the iso-

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(1) Dansgaard, W., The Isotopic Composition of Natural Waters, Meddelelser om Grønland, 165, 1-120 (1961).

(2) Epstein, S., Sharp, R.P., Oxygen-Isotope Variations in the Malaspina and Saskatchewan Glaciers, Journ. Geol., 67, 88-102 (1959).

(3) Craig, H., Isotopic Variations in Meteoric Waters, Science, 133, 1702-1703 (1961).

(4) Gonfiantini, R., Togliatti, V., De Breuck, W., Picciotto, E., Tongiorgi, E., in preparation, (1962).

topic seasonal variations in the precipitations (5).

The application of isotopic techniques to hydrologic research sometimes becomes difficult owing to the complexity of the meteorological model and to water mixing in the soil. Possibly these difficulties explain the scarcity of works in this field of isotopic geochemistry. However, the isotopic method can sometimes be used successfully; here some applications to hydrological problems are reported and an extension of the results to more general problems is attempted.

Two or more waters in nature can be considered traced when they have different isotopic compositions. This may be the result of:

a) a difference in geographic origin connected with altitude or latitude effects;
b) a difference in the contribution of rains fallen in different periods during the year (seasonal effect);
c) a difference in evaporation which the waters may have undergone.

For some very simple hydrological problems it is sufficient to note a difference in the isotopic compositions of the bodies of water being studied, but usually the isotopic effects due to the above mentioned processes must be known. The isotopic fractionation cannot be exactly estimated on the basis of a model only giving a general picture of the phenomena; moreover a direct evaluation of the original isotopic composition of each water would require a long series of analyses. The problem must be then considered from a practical point of view in order to see how useful date easy to be measured can be obtained.

For this purpose let us consider the hydrologic budget in the general case of a region in which the water contribution given by the precipitations is equal to the sum of the losses due to the evaporation and to the run-off; the resident water is given by the aquifers and the lakes.

For the understanding of the isotopic balance of such a model, the following relation based on the isotopic mass conservation can be used (6):

$$\delta_s = \frac{Q_v \delta_v + Q_r \delta_r}{Q_v + Q_r} \qquad (1)$$

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(5) Epstein, S., Communication in "Symposium on the variations of the regime of existing glaciers", Obergurgl (Austria) (1962).

(6) The δ-notation is defined as the deviation in parts per mil of the ratios D/H or O^{18}/O^{16} in the sample with respect to the standard SMOW (standard mean pcean water). A δ = +3 (or -3) means that the sample is enriched (or depleted) in heavy isotopes of 3‰ relative to SMOW.

where δ_s is the mean composition of supply water, δ_v the mean composition of water lost by evaporation, δ_r the mean composition of water lost by run-off and Q_v and Q_r are the quantities of water removed by the evaporation and the run-off (7).

As fractionation can not occur because of the run-off mechanism a tracing of resident and run-off waters with respect to the supply water can be expected only by evaporation.

Three ways of evaporation have to be taken into account: (i) evaporation from water surfaces (lakes, rivers), (ii) transpiration of plants, (iii) evaporation from the soil.

During evaporation from water surfaces, light water evaporates preferentially with respect to heavy water so that the residual liquid is enriched in heavy isotopes becoming traced.

On the contrary as detectable isotopic fractionation can not be expected in the absorption of water by the plants, the water in the soil does not change its composition by mean of this process. The only isotopic effect due to transpiration is a tracing of water in the leaves.

In a similar way the evaporation from the soil removes water from the capillary fringe which absorbs continuously water from the under lying aquifer, probably without isotopic fractionation and any isotopic enrichment cannot be expected in the aqui fers.

A general constancy with time for the isotopic composition of aquifers has been observed in several wells in Tuscany and Latium. The absence of an appreciable enrichment during summer shows that, in spite of a large amount of water lost by evaporation from the soil and by transpiration from the plants, these processes are, as supposed, practically ineffective for isotopic tracing of ground water.

Let us now consider a watershed with a free evaporating water surface representing a small fraction of the total surface. In this case no significant fractionation can arise from all evaporation processes. Then it follows from (1) that the mean isotopic composition of the supplying waters (δ_s) must be the same as that of the run-off water (δ_r).

The average isotopic composition of a river water collected in the lowermost part of the watershed can therefore be representative of the mean isotopic composition of the supplying water in the watershed.

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(7) Gonfiantini, R., Togliatti, V., Tongiorgi E., in preparation (1962).

This happens when evaporation from the river itself is negligible: otherwise evaporation can trace river water with respect to supplying water.

This conclusion was confirmed by the study on oxygen composition of water samples collected during a year in three rivers of Tuscany: Arno, Serchio and Era. In this case summer evaporation is not important for the balance of these rivers because of their small volume-flow in this season: any summer enrichment disappears in weighing the yearly mean isotopic composition.

The average δ-values are in good agreement with the δ-values of the rains as they can be inferred considering the different characteristics of altitude and the geographical position of the three watersheds.

For the Serchio river, with a mountainous watershed, an average value for δ of -7.6 was found. For the Arno river in the watershed of which mountains, hills and plains are present, the δ was found to be -6.7. For the Era river, flowing in a hilly region, the δ was found to be -6.4.

Such differences in isotopic average composition due to latitude, altitude or continental effect on annual distribution of rains, can be considered as a primary tracing of waters.

A hydrological application arises from the possibility that different primarly traced waters inflowing into an area to be studied, can be distinguished one from another.

Within each zone any deviation from the value corresponding to the primarly traced water, can be considered as a second order tracing.

This one can depend on seasonal variations or local conditions of evaporation. For istance, differences in isotopic composition of river water samples collected at different times during the year correspond to a second order tracing as compared with the weighed mean annual isotopic composition of river water.

In the case of the above mentioned three rivers of Tuscany, different periods with characteristically traced waters can be considered with regard to the climatological condition of the region. The comparison between river isotopic composition and average flow during a ten days period before each sampling (figures I and II: curves 1 and 2) shows how the seasonal variation in isotopic composition of rivers can be related to the isotopic composition of the rain.

Winter and spring rains falling on a saturated basin cause a sudden strong increase in the volume flow. The light water observed in these periods obviously reflects the precipitation

on the watershed during preceding days. In this way no general definite value can be considered for winter and spring waters in a river as they are strictly related with rainfalls. But during relatively dry periods in winter and in spring the isotopic composition of the river water tends to assume a constant value.

Later in time in connection with the summer dry period, the δ -values increase and rapidly approach the maximum observed in September. The summer isotopic composition of the river water cannot be ascribed to high content in heavy isotopes in summer rains as they have been observed also during summers without any precipitation.

Finally autumn rain causes both an increase in volume-flow and a decrease in δ -values. These are nearly constant and similar to the values observed during the dry periods of winter and spring.

Concluding, the three considered rivers show two characteristic δ -values: the summer and the autumn ones. The first one is higher than the autumn value, which in turn is nearly the same as that observed as a constant value in aquifers.

This last fact can be understood taking into account that: (i) The summer lowering of the level of aquifers is compensated by autumn rains (from curves 2 and 3 in figures I and II it can be seen that the volume-flow of the rivers in September is not increased in spite of the large amount of precipitations in this month). Furthermore the largest part of the precipitations reaches aquifers in the season of dormant vegetation. (ii) Winter and spring rainfalls flow in greatest part on a saturated soil and summer rains, if present, are negligible; so the main contribution must be due to the autumn precipitations. Possible contributions in other seasons does not affect the isotopic composition of the water since mixing in the aquifers occurs.

As a consequence of the filling mechanism of aquifers the average isotopic composition of their water cannot be the same as the year weighed average composition of water in rivers.

In Tuscany however these two values are very close. This is because autumn and spring precipitations which have similar isotopic composition represent the greatest part of the total amount during the year. Furthermore a great amount of water flows slowly underground reaching surface watercourses after a long time. This contribution can be responsible of the fact that in dry periods during winter and spring the water of rivers in Tuscany tends to have the same isotopic composition of the autumn water.

From these facts it results that, instead of checking the isotopic composition of water in a river over a year, it would be possible to obtain information on the first order tracing in rivers of Tuscany only from a few samples collected in the aquifers and in the rivers during the autumn. In any case a proper period for sampling can be deduced from the annual distribution of precipitations.

The summer value of the isotopic composition of water in the rivers of Tuscany must be considered in relation to the absence of precipitations in this season. In this condition one can write (7):

$$\delta_r = \delta_a + \frac{Q_v}{Q_a}(\alpha - 1)1000 \qquad (2)$$

where Q_v is the quantity of water evaporated from the river, Q_a is the quantity supplied to the river by aquifers, δ_r is the isotopic composition of water in the river, δ_a is the isotopic composition of water in the aquifers and α (about 1.01 for oxygen) is the fractionation factor between liquid and vapour water.

When evaporation from the rivers is far from negligible, as in summer, it is evident from (2) that δ_r must be more positive than δ_a, as found in the rivers of Tuscany.

The evaluation of the amount of water drained by the river on the basis of (2) can be affected by great errors due to the uncertainty on δ-value; but relative evaluation of drained water along the river avoids this difficulty.

As a particular case it appears that when the summer isotopic composition along a river is constant, as has been observed for the level part of the course of the Arno river, the drainage from aquifers must be constant too.

To obtain these conclusions it is necessary to assume that, after the last spring rains, there has been time enough for river waters to acquire the composition that they would have in steady conditions. This assumption is confirmed not only by theoretical considerations but also from evidence that, in all the observed cases, the seasonal curve achieves the summer maximum in an asymptotic way.

In the case of large water surfaces hydrological applications of tracing due to evaporation become more evident.

A model of the isotopic enrichment has been developed (8). The isotopic composition δ_l of a lake with a constant level and in steady conditions depends on the isotopic composition δ_s of the supplying water, on the fractionation factor α between liquid and vapour and on the ratio X between the amount of water lost by evaporation and the amount of supplying water:

$$\delta_l = \delta_s + X(\alpha - 1)1000 \qquad (3)$$

If the evaporation is very low with respect to the water supply, and the level is kept constant by an important outlet, the X-value is practically zero and the isotopic composition of the lake is equal to δ_s; on the contrary if there is not any outlet and water is lost only by evaporation, the X-value is equal to 1 and the maximum enrichment in heavy isotopes is reached by the

(8) Gonfiantini R., Togliatti V., Tongiorgi E., Il rapporto O^{18}/O^{16} nell'acqua del Lago di Bracciano, Notiziario CNEN, Giugno 1962.

lake. As a consequence the water in the lake can have an isotopic oxygen composition varying from that of supplying water to another one about 10 δ-unities more positive.

Some lakes of Central Italy, practically without outlet, have water with a high oxygen-18 content, as example δ = +2.0 in Trasimeno lake, δ = +0.7 in Bracciano lake. In the same region aquifers and rivers have an isotopic composition suggesting a value of δ = -6.5 for the average isotopic composition of supplying water.

This remarkable tracing have been succefully used in order to establish if and in which amount the water of the lake contributes to the aquifers surrounding the lake.

It must be noted that in so far as the maximum depth of Bracciano lake is 160 m, the isotopic composition of the water is constant. On the contrary, surface samples show small seasonal variations from the value observed in depth.

From these data can be deduced that the lake has attained an isotopic steady state.

On the basis of the amplitude of the seasonal variations in surface waters, a mixing rate of about 10 meters per year has been extimated.

Any sudden change in the hydric budget of a lake will be reflected in a tracing of the upper layers with respect to the underlying layers. In the isotopic composition of water at increasing depth a record of the history of the lake is so preserved for a period of time depending on depth and mixing rate.

The examples and considerations as given show that in some cases with the isotopic methods results that are difficult or impossible by other methods, can be obtained.

The few data available at present with regard to the variations in the isotopic composition of natural waters reduce the number of possible hydrological applications. In addition, because of the not yet perfect knowledge of the tracing processes' mechanism, with particular regard to the values of the fractionation factors between liquid and vapour in natural conditions, the possibilities of surveying are further limited.

In these conditions no general rule for isotopic research in hydrology can be established; in every case the methods of solving the particular problems will be suggested either by the local interests on informations which can be obtained or by the possibility of knowledge of the necessary parameters.

A research which in some conditions cannot assure results, can be fruitful if undertaken in regions in which geographical or climatic conditions cause a strong tracing of water.

The results obtained in a region not favourable from this point of view confirm the conviction on the utility of isotopic methods.

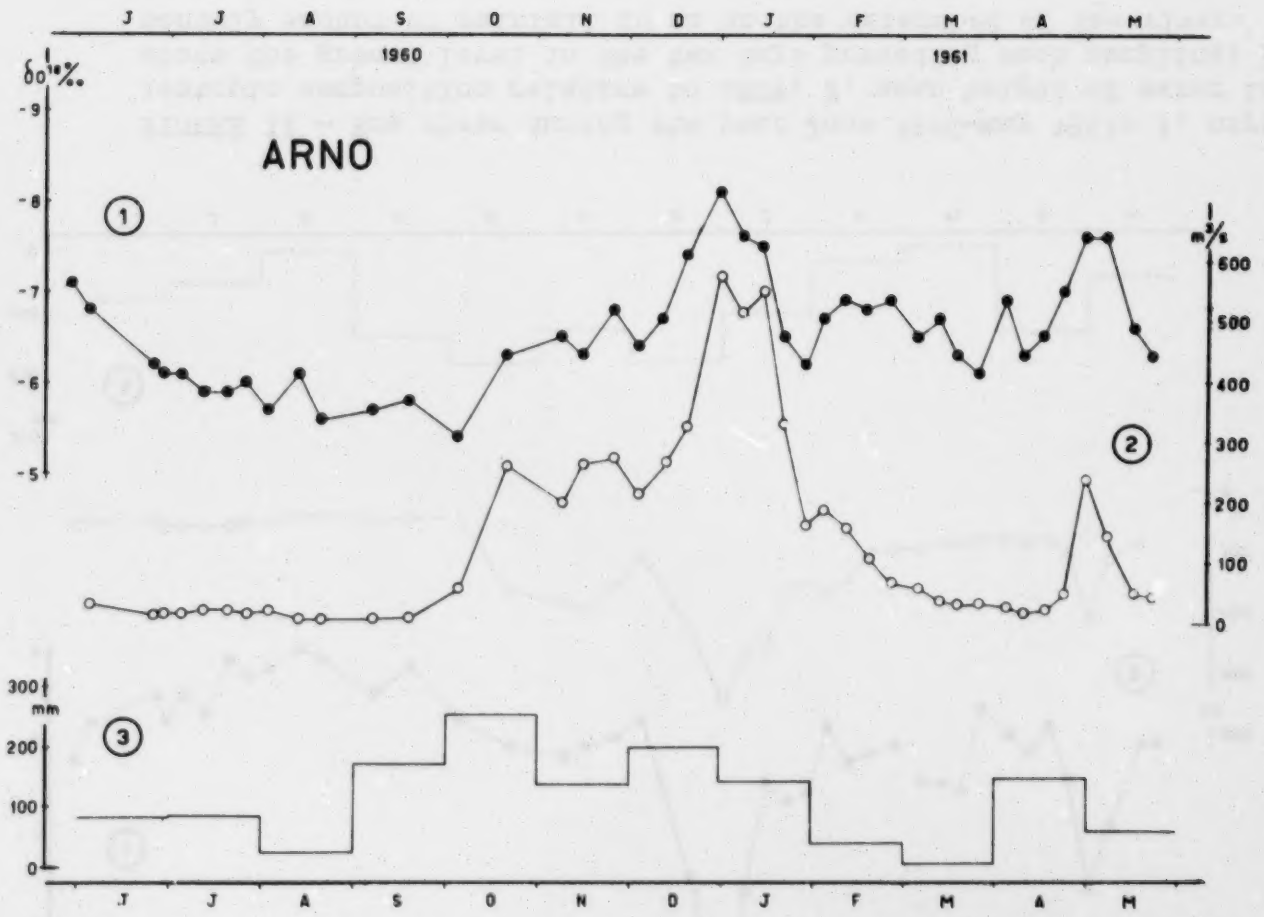

FIGURE I - Arno river during the year June 1960-May 1961: 1, oxygen isotopic composition relative to SMOW; 2, mean volume-flow in m /sec in the ten days preceding each sampling; 3, montly amount of rainfall in mm on the watershed of the river.

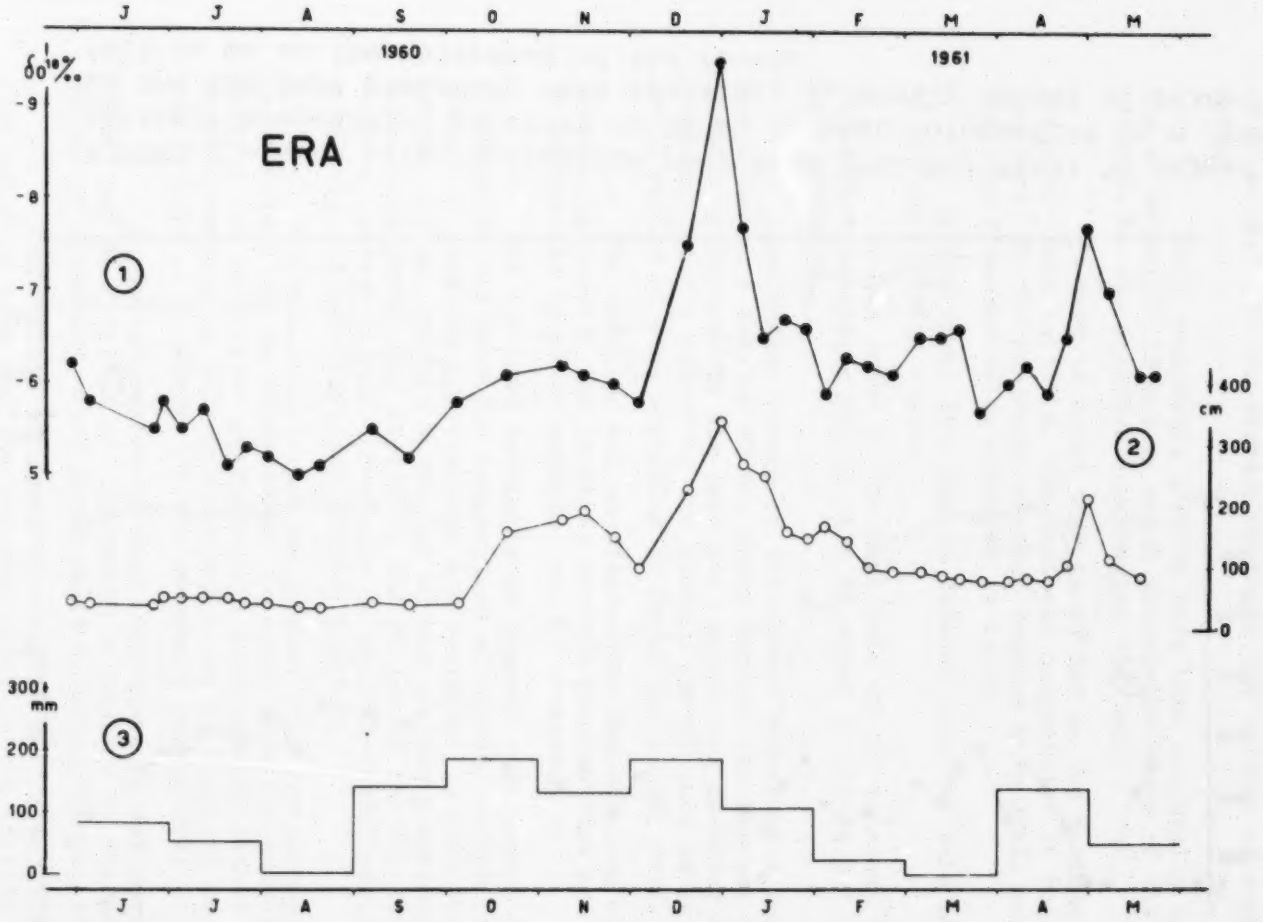

FIGURE II - Era river during the year June 1960-May 1961: 1, oxygen isotopic composition relative to SMOW; 2, mean height of water in cm above the ground level in the ten days preceding each sampling; 3, monthly amount of rainfall in mm on the watershed of the river.

957 E - Oct.1962 - 1,600

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United Kingdom

DEVELOPMENT OF NEW HYDROMETRIC EQUIPMENT AND GAUGING STRUCTURES ON STABLE RIVERS

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DEVELOPMENT OF NEW HYDROMETRIC EQUIPMENT AND GAUGING STRUCTURES ON STABLE RIVERS

by

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INTRODUCTION

1. Hydrometry (the measurement of water, especially of the quantities, the levels, the velocities and the rates of flow or discharges) is an essential foundation for any measures aimed at the development, use or control of water resources. It is a distinctive feature of hydrometry that useful surveys are not only extensive in area but protracted in time.

2. The scientific bases of hydrometric methods and instruments are the same as those applied in many other sciences and technologies. The practical use of equipment similarly requires operators with skills which could equally usefully be employed in other fields. Those parts of the world in which hydrometry has become an established activity are, on the whole, populated by inhabitants accustomed to (or at least familiar with the idea of) measurement, to engineering control of the forces of nature, and to political and economic co-operation for the development of natural and other resources; living in countries most parts of which are easily accessible; and expecting perhaps a speedy, but hardly an "explosive" expansion of water development. The hydrometric instruments in common use today are relatively simple instruments requiring for a satisfactory survey large numbers of competent operators able to use them with both skill and judgement.

3. In less developed areas, the shortage of skilled man-power, the need for the most rapid possible advance on all frontiers of human activity, and frequently the difficulties of access and local support, all suggest that
   (a) the hydrometric survey be wide-spread in area and, with an early start, continuous in time;
   (b) the equipment used be capable of yielding all required answers with a minimum of investment of skill and judgement in installation, maintenance, servicing, checking, and reporting; and
   (c) both personnel and equipment be independent of local support and safe from unskilled or unsympathetic interference.

4. Requirements (a) and (b) above apply to all hydrometric surveys on which water development is to be based, wherever that may be, but there may be a difference in emphasis depending on the desired rate of development of water resources and the amount of information already available. Good hydrological analysis must be the foundation of good hydraulic design. If there are not enough records to permit a good hydrological analysis, and if hydraulic works are overdesigned or underdesigned, any subsequent collection and analysis of hydrometric data will indeed show up the error: but the cost of subsequent expansion of the works (if underdesigned), or the unnecessary excess in first cost (if the works were overdesigned), would probably greatly exceed the cost of speedily establishing and continuously operating a wide-spread hydrometric network.

5. The design of the best hydrometric networks requires a skilful team with a proper understanding of the personnel and the material resources available for surveys on the one hand, and of the technological and economic aspects of the desired water developments on the other. If for no other reason, new hydrometric equipment and methods have to be, and are being, developed because the desired size and timing of developments economically justifies larger surveys than the available personnel can undertake with older equipment.

PURPOSE OF MEASUREMENT AND AIM OF EQUIPMENT

6. In surface hydrology, the purpose of measurement is to obtain a knowledge, required for utilisation and control, of the quantity and variability of water quantity (level and discharge) and quality (other substances dissolved and solids suspended in the water); in particular, depending on the conditions in a locality or in a whole river basin, a knowledge of annual, seasonal, monthly, weekly or daily averages and of the magnitude, duration and frequency of maxima and minima. High water levels are of direct interest in flood control, and low levels in connection with the maintenance of navigation depths and of depths at artificial intakes. Indirectly and after calibration, levels are used as indicators both of discharge and of quality.

7. The aims of the equipment and of the method of its employment are: accuracy, completeness of coverage; ease and speed of operation; security of installation; economy in equipment and in skilled manpower; portability of instruments; and results permitting accurate, speedy and economical analysis.

DEVELOPMENT OF NEW HYDROMETRIC EQUIPMENT

8. Water level or "stage", is measured by means of staff gauges (vertical or inclined scales: rods, tapes), and where personnel is available this simple principle will continue to be used, especially for check readings for more complicated equipment. Special refinements are provided for the recording of maxima, and these involve the use of floating slides or of soluble dyes. Where a knowledge of the duration of a flood peak above certain levels is required and continuous recorders for such high levels are considered uneconomical, large calibrated containers with small orifice inlets at the specified levels may provide a cheaper solution. In order to allow levels to be measured more accurately, stilling wells are installed and provided with point or hook gauges or with floating staff gauges -- these are especially useful for precise check observations.

9. If continuous level records are required, floats in stilling wells are often employed to actuate indicators or recorders. Electrical (capacitative or resistance) devices are occasionally used in lieu of floats. The usual recorder is a chart device driven by a clock. In easily accessible places, weekly or even daily charts are used, but modern developments in battery-driven clocks now make it possible to operate strip charts for six months or more without attention.

10. Another type of level recorder operates in response to hydrostatic pressure changes brought about at a fixed level by the variations of the water surface. Until recently, the only reliable mechanism operating on this principle was a "bubbler" tube, fed from a compressed-gas bottle at a rate sufficient to ensure that in no flood, however sudden, would water be able to enter the tube. There must, therefore, be a steady, though slow, supply of gas into the tube. The pressure in the tube (which balances the water pressure at the tube outlet) is recorded on a barograph. The usual gas employed is air, either brought to the gauging site in high-pressure bottles or compressed, at intervals of a few

weeks, by means of a site pump; but some recent experimental "bubbler" apparatus is said to employ nitrogen or rare inert gases.

11. Another pneumatic water-level indicator, distinguished for its simplicity and cheapness, has now been improved to the point where its accuracy and durability seem to be assured. It is in essence a closed bellows anchored securely to the stream bed and also recording on a barograph. Whilst there should be no loss in gas, the sensitivity and accuracy of the indicator are lost if there is any kind of change in the elastic coefficient (or "aging") of the bellows.

12. The recording instruments are usually chart recorders, either with circular (rotating disc) charts on which the angle represents time and the radius the water level, or - more frequently - with cylindrical charts. If the timing drive rotates the cylinder, the range of paper over which water-level variations are recorded is limited by the height of the cylinder. This usually leads to a loss of accuracy in the recording of the lower and near-average levels which prevail for the greater part of the time, if provision is to be made for records of the highest possible levels. One way of overcoming this difficulty is to gear the drive for the level-recording pen logarithmically so that the scale progressively increases as the water level falls. Another method of increasing the scale consists of so designing the pen gear that the height of the cylinder represents the normal range of water-level variations and any unusually large rise causes the direction of the pen travel to be reversed.

13. The advantage of a chart which follows a cylinder rotating with time is that the chart may be a very long strip making the recorder largely independent for long periods (up to, say, one year: see paragraph 9). For most rivers, by far the greater part of such a long strip is apt to contain a trace with little variation, but with some short sharp peaks (representing floods). In the interest of economy of paper and evaluating effort and, especially, in the interest of accuracy, it appears desirable to design a timing drive with two speeds - slow for low levels with slow variations and rapid for the higher levels with pronounced change. The use of such two-speed recorder charts may also demand a revision of the equipment used in evaluating results (e.g. special planimeters). A useful speed ratio might be as high as 20:1.

14. The cylindrical recorder with an axial time drive permits rotation beyond 360° and so, in theory, gives unlimited freedom of choice of water-level scales for a given size of chart. Its disadvantage lies in the necessity to change the chart (or, at least, to reset the pen) when the time corresponding to the length of the cylinder has elapsed. For use in inaccessible places, a recorder with a device permitting automatic resetting of the pen at the end of the design period would perhaps be of advantage.

15. Until recent years, the only type of recorder used in hydrometry was the "analogue" in which a pen or stilus traces a line on a paper chart or a metal sheet. In the past decade "digital" devices have been developed which usually leave a record in the form of a punched tape. In principle, the gearing of digital recorders is as simple as that of the analogue ones, but various refinements common in other modern industrial applications of recorders tend to be incorporated in them so that their cost is still relatively high. Punched tape has the great advantage of permitting immediate high-speed analysis by modern computers, including a type of "auditing" or verification of the validity of the records.

16. The subject of recorders is of great importance in hydrometry, for the greater part of the best surface-water data is derived from these instruments. The older type, installed in accessible places and serviced by skilful technicians, gives reliable and fairly economical results. For the large hydrometric programmes likely to be needed in less developed countries, however, and for special purposes such as flood forecasting, the older type is wasteful of skill and time, and the potentialities of the new developments deserve to be studied in full. The main advantages of digital devices in this respect derive from the fact that they generate and transmit their information in the form of finite steps or increments or pulses which are comparatively insensitive to disturbances and, incidentally, readily lend themselves to magnification. Both for inaccessible stations, therefore, and for those from which information is required very speedily (for forecasting), the newest radio or telephone-reporting apparatus seems e[illegible]: so far the equipment under test is still costly aswell as apt to give occasional trouble, but the operating principle of transmitting information on water levels at regular intervals, or on request, usually in digital form, is so simple that speedy improvements in design and construction may be confidently anticipated. The conclusion to be drawn from this is that a small but skilful team, perhaps made highly mobile by a helicopter, will soon be capable of installing and servicing a basic network of radio-reporting recorders, with a secondary network of local tape recorders, covering a river basin extending to t[illegible] of thousands of square miles.

17. The indirect use of water levels as indicators of discharge is very common. This requires a calibration process usually yielding a stage-discharge curve or a family of such curves. The most common method of calibration is by means of the velocity-area method and more particularly by the use of current meters placed successively at points of measured distance from the river bank and depth below water surface. The cup type of meter is comparatively cheap, robust and insensitive to silt and seems to be approaching the limit of its possible development. It reads the maximum velocity in the plane perpendicular to its axis, with a slight speeding up if there is an axial flow component, and therefore tends to over-record discharge. The screw type ("propeller") has a speed response to the flow velocity which may be arbitrarily chosen in terms of the pitch; its size brings the ideal of measurement of point velocities nearer; and modern developments of blade shapes ("cosine-reading") permit the axial velocity component to be recorded, which is desirable if the instrument axis can be held parallel to the river axis or if the meter could be provided with an instrument indicating exactly the position and direction of the axis. To give a good velocity reading at any point, the current meter must be held there for at least two runs of at least 30 seconds each. Cosine-reading meters permit a considerable speeding up of the process: a traverse of the cross-section of the river in a series of verticals or in a zig-zag pattern provides its own integration to yield the direct result of the total discharge.

18. In a large river, the difficulty of accurately determining the size of the channel cross-section and the position of the current meter (especially if suspended from a boat) is great. Speed and accuracy of observation may be improved by the replacement of horizontal tapes and of sextant or theodolite controls by Radar or Sonar measurement, and by the replacement of sounding rods and cables by echo-sounders.

19. Alternatives to current meters for the measurement of local velocities are the speedy and sensitive pressure (Pitot or membrane) or hot-film devices, which may repay further industrial development. Freedom from silt clogging of propeller meters may be brought about by improvements in the design of rotor bearings and by magnetic or capacitative couplings of the rotor to a completely sealed recorder.

20. A direct measurement of the mean velocity may be obtained by timing the passage through a measured length of river of a suddenly injected chemical or radio-active indicator ("salt-velocity" method). Present developments aim at ensuring that the indicator is representatively spread across the whole section of the river and that the material chosen is not affected by the bed material.

21. If chemical or radio-active tracers are permissible and suitable, the direct measurement of discharge by the "salt-dilution" method is usually preferable to the velocity method. Here a tracer is injected into a river at a known constant rate and concentration and, when completely and uniformly mixed with the natural discharge, indicates the magnitude of that discharge by the reduction in its concentration. Experiments continue to provide us with chemicals of the required degree of inertness and capable of being accurately measured in minute concentrations: it may be expected that this form of hydrometry will become much more prominent in future.

22. A major difficulty in establishing the stage-discharge curve for a river section by any velocity-area method or by salt dilution lies in the need for repeated observation to establish numerous points on the curve, with little chance of being present during the infrequent extremes. Even if the team is present during a flood, the dangers and practical difficulties of observation are very great.

PRINCIPLES OF "CONTROL"

23. In open-channel hydraulics, the term "control" denotes an artificial weir, notch, flume, or culvert, or a natural rock bar or other obstacle, which permits the instantaneous discharge to be uniquely related to one or two water levels. "Free" flow occurs if the Froude Number at the control section exceeds unity. With a free flow over the whole range of discharges, a single water-level recorder installed at (or a short distance upstream of) the control provides continuous information on discharge. In nature it often happens that over part of the range the flow is "submerged", but it is usually found that continuous records of water levels at the control and at a suitable section upstream, while requiring double the instrumentation, will still economically provide accurate information on discharges.

24. Where a control occurs at considerable distances from river junctions, a single water-level record suffices to indicate "submerged" discharges, but the method of establishing a stage-discharge curve in that case is likely to be a velocity-area or salt-dilution programme: the advantages of "pure control", as obtained in weirs etc., are lost.

25. If "pure control" is available, the degree of accuracy of discharge computation may be as high as desired and -- a most important advantage in a "crash" programme -- the whole of the stage-discharge curve may be accurately established without waiting for extreme discharges to occur in nature.

26. Entirely artificial structures, even more than modified natural controls, have the great merit of giving the designer considerable latitude in determining the accuracy of discharge computation corresponding to a given accuracy of level measurement at various stages. Artificial gauging structures may be built to standard dimensions for which the stage-discharge curve has already been determined. Non-standard structures and natural control sections have to be calibrated, and the best calibration is by means of scale models.

27. On the basis of mechanical similarity, models of control structures (in which gravity forces predominate over viscous and surface-tension forces) are built to a reduced scale without distortion. The predominant similarity criterion is the Froude Number, and the discharge ratio is accordingly very nearly $r^{2.5}$ (where r denotes the linear scale ratio). To allow for "scale effects", e.g. the minor effects of the lack of similarity of the viscous forces, corrections are applied which are based either on experience with past model calibrations for similar structures or on studies on several models of the given structure built to various scale ratios.

GAUGING STRUCTURES ON STABLE RIVERS.

28. The hydraulic design of weirs, notches and flumes is a well-documented branch of hydraulic engineering. On very large rivers, the provision of artificial structures solely for gauging pruposes is likely to be too costly and protracted an undertaking to be of practical interest. It should, however, be borne in mind that the construction of any dam, barrage, bridge, embankment with culverts etc. provides control sections of known dimensions: single or twin water-level recorders will yield a good basis for hydrological work.

29. Stable rivers are those where the variation with time of the cross-section is negligible. In practice this occurs where rivers flow over a rocky bed, and is not so rare as has been suggested. Even where rivers move through vast alluvial plains, artificial stabilisation of the bed and banks, especially at structures built for water-control purposes or at bridges, may be a practical proposition.

30. On many rivers on which a major gauging programme will become necessary in the near future, preliminary surveys will reveal cataracts, gorges or sharp rocky bends, as well as the rock bars forming the classical equivalent to a gauging weir. As the quality of a hydrological design for the control and use of water is a function of the duration of record, in most cases, it is of great importance to establish water-level recorders at one or more of such natural controls at the earliest possible moment. Checks of the stability of cross-section may be made two or three times a year - perhaps before and after a flood season - but the second main purpose of such checks will be to build up a survey of the shape of the river in the vicinity of the control. The construction and calibration of one or more scale models may wait until a detailed study of the water resources is ripe: with a long water-level record and a stage-discharge curve deduced from a good model calibration, a very accurate picture of the averages and of the variability of the surface water resources in a basin may be obtained at a remarkably small cost and with a very brief employment of highly skilled personnel.

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UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item: A.4.1.2

Economic Commission
for Europe

EVALUATION OF FORESEEABLE ENERGY REQUIREMENTS

By The Energy Division
of the Economic Commission for Europe

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.

3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

4. Papers and summaries will not be available for general distribution in advance of the Conference. They will be published in advance in limited quantities only for the use of delegations of participating governments and of other authorized participants. Post-Conference publication and general distribution of the Conference Proceedings will follow United Nations practices as laid down by the United Nations Publications Board.

EVALUATION OF FORESEEABLE ENERGY REQUIREMENTS

by

The Energy Division of the Economic Commission For Europe

I. Introduction

1. The difficulties which confront newly developing countries in evaluating their needs for inanimate energy are clearly greater in general than those - already fraught with hazard where the energy economy as a whole is concerned - which face countries already highly industrialized. These difficulties are of various kinds. They commonly stem from a lack of reliable time series - both for basic economic indices and for data on different types of energy use by the main categories of consumers. Moreover, relationships between sets of data which should yield slowly evolving "elasticity coefficients" are likely to be irregular. Magnitudes involved are small, so that new installations also impart a step-like character to the growth trends. Consumption tends to be limited by production possibilities. Thus the building, say, of a sizeable hydro-electric plant may attract to the region concerned a body of consumers which soon assumes a "snowball" character, so that the regional estimate of requirements quickly becomes obsolete. Prices paid for such commercial forms of energy as are available are usually high and serve to distort the latent pattern of demand which eventually must emerge. Short-term allocation of capital expenditure between different priorities may have a similar effect. Finally, the development trends in different regions of the country may be largely unrelated to one another, in part because of the lack of any nationally integrated energy supply system.

2. The main problems which face more developed countries are either those which arise from fluctuations in economic activity, and possibly from changes in interest rates and purchasing power imposed by government fiscal policy: or those which underlie the substitution of one form of energy for another - differences in rates of technical progress in different fields; in availability and relative cost of different sources of energy outside the country; and sometimes the effects of new discoveries or the using-up of indigenous energy reserves. It is often difficult to distinguish the one basic source of variation from the other. Inadequacy of statistical data remains a problem to some extent - for example, in respect of the socio-economic characteristics of retail consumers.

3. In essence many of the problems of assessing energy requirements in highly developed countries are shared by or are at least incipient in those where development is at an earlier stage, much of the difference in practice being due to the greater stability and comparability of trends in time series in the former group owing to much higher, more diversified and more evenly distributed levels of consumption per head. Factors responsible for these differences in the basic situation must generally be expected to diminish, rather than to increase, in the future. Some forms of analysis available in highly developed countries - Leontief input-output

matrices, for example - cannot be applied at all in those at a much earlier stage. Nevertheless, lessons which have been learned comparatively recently in the former group under conditions existing during the post-war period may usually be instructive for the latter, and may allow them to build on somewhat surer foundations.

4. It is sometimes stated that while all countries have energy requirements not all possess natural energy reserves, so that in newly developing countries requirements should be taken as the point of departure. On a long-term view this idea is contradicted by experience, particularly in Europe, where nearly all countries may be arranged in a series varying from those possessing (or using) an abundance of coal and little or no hydro power to those where hydro-electric resources are very great but are virtually (apart from fuel wood) the sole internal source of energy. The structure of the energy supply, the relative importance of electricity and of industries which require large quantities of kWh at low cost, the use of electric energy in the home and for other low-voltage uses - these are broadly correlated with this basic pattern of natural resources. Differences which remain are largely due to geographical position affecting fuel imports and general trade; the presence or absence of other non-energy resources; and, of course, the level of total national product per inhabitant already reached. This last is important because recent research seems to show that the evolution of energy requirements in response to economic development involves a distinctive development process, in which primary energy needs, and in particular the role of electricity therein, grow at rates which do not remain simply proportionate to industrial production or even to total national product.(1)

5. Methods of evaluating future energy requirements differ according to the source of energy concerned. They must therefore be considered so far as possible, in relation to the foreseeable pattern of internal commercial energy reserves (future changes in use of non-commercial sources must be allowed for also) and to the expected composition and source of the energy supply as a whole. With this in mind it will be worth while to review first the essentials of the different methods of planning and forecasting available where sophisticated methods are at least possible and then to consider how far these are relevant to countries at earlier stages of development.

II. Methods of evaluating future requirements

6. If we consider this problem as one of satisfying a country's energy needs as economically as possible, then methods of forecasting form only one group of a series of related analytical and planning procedures which must eventually be considered in conjunction with one another. At this point it is the methods of projecting future requirements, mainly for medium-term estimating for, say, 5, 10 or 15 years ahead, that are taken into account.

7. Methods of arriving at future energy needs in an economy where production of goods and services is rising may be reduced to the following:

- direct extrapolation of rates of change in requirements based on analysis of past experience;
- extrapolation from functional relationships between two or more variables, one of which is that to be forecast;
- extrapolation of requirements per unit of product applied to planned or expected production;
- evaluation of a development trend from comparative study of its homologues in different countries.

8. In practice these methods may well be used as alternatives to check one another. In such a case it is common for one or more methods to be applied to deduce future requirements by different main consumer-groups, and possibly also in different regions, and then to bring together the results. One or more alternative methods would then be applied on an overall basis to see how far the results conform to the expected development of the economy as a whole.

9. Different forms of energy show widely different rates of growth in requirements. Some are also far more sensitive than others to fluctuations in economic activity (2) and also more vulnerable to competition from other energy sources. The range of methods available for use thus varies from one form to another, and it is common practice to estimate needs for forms of energy which are residual or the least competitive by difference, after defining requirements for those types of use which are the more dynamic. There is thus an order of forecasting to be considered if all main forms of energy are to be taken into account in a co-ordinated series of projections. In practice, however, the emphasis in most energy projections is placed on electric power needs, which nearly everywhere have for long been growing at a high exponential rate. and playing an ever-greater role in the total energy supply. In a number of countries coal requirements, other than those for coking or for use in power plants, tend to fall at the opposite extreme.

(a) Direct extrapolation of rates of change

10. In practice this procedure is very widespread and must often be used in less developed countries. Various methods may be used to arrive at an average rate of change per unit period from the historical data after these have been corrected for such influences as normal seasonal variation, the effects of abnormal stoppages (3), and in suitable cases for the effects of departures from normal conditions during the winter heating season (4). Some ways of deriving a selected exponential rate (i.e. one which projects as a straight line on a semi-logarithmic scale) from a short time series are outlined in reference (5). It is, however, good practice also to use a matrix Table for this purpose, each year in the series being listed in order both vertically and horizontally. The average percentage rate for every combination of periods is then inserted in the appropriate cell. In this way it is possible to see at once how far rates for different periods have varied and to select that which is considered most significant for projection purposes.

11. Another method of extrapolation is sometimes used involving exponentially weighted moving averages. This consists in selecting the chosen value in such a way as to give more weight to the most recent rates experienced (6). It is possible to derive formulae of this type which at the same time allow for seasonal fluctuations in the data.

12. Projections based on empirically determined degressive formulae (7), or on expressions giving a modified exponential curve, a logistic or "S" curve or a Gompertz curve determined from analysis of past time series (8), all fall within the category of direct extrapolation from past trends. In most cases these methods are over-ambitious in the circumstances discussed here. It is, however, possible that the acceleration reflected in the lower portion of a logistic trend may have some importance. This question is referred to below in connexion with comparative international studies.

(b) Extrapolation from functional relationships

13. This method may be used in a complex way, involving the working out of many relationships for different sectors of the economy so as to arrive at an overall econometric "model" which must be revised periodically; or it may imply a use of

simple relationships found between energy requirements and such overall economic indicators as are available. In the latter case simple or multiple regression equations expressing linear or non-linear relationships may be used; but in the present context the simple "elasticity coefficient" obtained by dividing one index of change by another (the two indices being referred to the same base year) may often be the more suitable. In suitable circumstances the relationships expressed by such coefficients evolve more regularly and change more slowly than do the actual data themselves. To give a very general example, while an index for total national product divided into one for total energy input expressed in kcal may at an early stage of economic development give a coefficient equal to or above unity, the gradual rise in average efficiency of energy use is likely to reduce it to a value of around 0.8 at a much later stage.

14. In the case of electric power at least (the analogy may perhaps be extended) it is instructive to consider rising annual requirements in kWh as the product of three main components - connexions of new consumers; the level of economic activity; and an electrification factor which reflects the extension of power to new uses. If C represents consumption and I is an industrial production index, the following expression is not untypical for some well-electrified countries:

$$\frac{C_1}{C_o} = \frac{I_1}{I_o}^{0.4} \times 1.05$$

Here practically all existing consumers are connected up and the factor for application to new uses is taken as 5 per cent.

15. This type of approach may be useful in less-developed countries only as a model for the use of judgment in estimating rather than as a statistical exercise. A formula of similar type has however been derived for the world on the basis of experience since 1937 (9). (see also Figure 1).

(c) Extrapolation based on the product of planned levels of activity and specific energy needs per unit

16. This method is sometimes employed very simply, as for example by applying to a population projection an extrapolation of average consumption per inhabitant. It is, however, also applied in great detail, using the planned output of each industrial sector, transport in ton/km etc., and projecting expected consumption per unit of product to obtain aggregate requirements for each different form of energy. This is the basic method used in preparing the economic plans of centrally-directed economies. In such cases method (b) above is commonly used as a check where long-term perspective plans are undertaken.

(d) Evaluation of development trends from comparison of tendencies in different countries

17. Comparison between trends in different countries can be based on the idea of direct extrapolation (method (a) above) or on that of extrapolation of relationships (method (b)). Where a particular energy category exhibits a more or less consistent type of growth in many different countries over a long period it is possible to compare:

- long-term changes in growth rates for single countries;
- short-term growth rates in different countries at the same time;
- growth tendencies in countries at widely different levels of specific consumption.

18. There is probably more scope for extending the use of this method than has so far been realized. When method (b) above is employed to study, for example, parallel developments in indices of economic activity, total calorific input of energy and electric power consumption for countries at different stages, the main lines of the likely evolution of energy requirements tend to emerge more clearly. The logistic or "S" curve development which characterizes so many economic and social trends can also be studied in its earlier stages where electric power is concerned, although the point of inflexion and the ensuing development stages cannot yet be established with any precision. This is in part because the trend of total consumption is compounded of a number of separate logistic surges, which can still arise in some fields of use.

19. For countries at the earlier stages of development this method of international comparison can be partially taken into account by comparing developments in demand elsewhere under more or less homologous conditions. While for instance annual rates of increase in a country's electric power requirements often tend at the outset to be rather low (around 5 per cent) they quite commonly appear to accelerate rapidly (to some 15 per cent or more) at around 100 kWh per head before declining somewhat at considerably higher levels of specific consumption (10).

III. Consolidation of energy projections

20. In most industrialized countries electric power requirements tend to be taken as the point of departure when consolidated energy projections are attempted. In recent experience future electric power demands have usually been under-estimated. This applies to total consumption and to forecasts of the maximum annual load to be met. In general it is found that continuing rapid growth nearly everywhere makes the consequences of under-estimating more serious than those which would be likely to follow from moderate optimism. The only proviso here for less-developed areas is that concentration on a large power project in a particular locality - say, an important hydro-electric scheme - without taking sufficient account of its effect on neighbouring localities (for example through their irrigation needs) and without ensuring either adequate transmission facilities or else immediate local demand expectations can, and sometimes does, mean that scarce capital will not be used initially to the best advantage.

21. Projection of electric power requirements tends to allow the greatest scope for sophistication so far as method is concerned. For less-developed areas it is likely to be sufficient to employ as many of the above-mentioned forecasting procedures as the available data allow in their simplest form, and making all possible allowance for personal judgement. It will usually be desirable to attempt to define requirements for each region separately and to compare their aggregate with a relatively simple national forecast to see how far conditions resemble those which may exist elsewhere. Where other energy needs are to be evaluated at the same time it has usually been found best to proceed by elimination, using whichever of the above methods of projection is best adapted to the conditions and trends of demand and supply for each form of energy, after taking the following criteria into account:

- degree of specificity of supply sector and freedom from substitution;
- constancy of trend and actual rate of change;
- closeness of correlation with other economic series;
- availability of data for the past;
- extent to which supplies depend on production possibilities;
- extent to which requirements can be estimated by difference.

22. Unlike forecasts required for plant construction programmes, comprehensive energy projections for general guidance can usefully be made as simply as possible and revised at frequent and regular intervals. Even in highly industrialized countries comparatively simple projection methods must often be used for some energy categories. Combining of the different estimates may then be a matter of reconciling alternatives based on different assumptions, for example as to future price ratios per calory for some competitive uses of coal and liquid fuels. Alternative estimates of growth in total national product and industrial output at least may have to be employed also.

IV. Study of requirements in relation to evaluation of natural resources and total system planning

23. It is difficult to overestimate the importance of making surveys of water resources and natural fuel reserves in a comprehensive manner at the earliest possible stage (11). The same remark applies to other natural resources of energy-consuming importance. Rapid preliminary assessments will be inaccurate in various respects. If they employ common methods throughout the entire country they will nevertheless serve to throw light on three important questions: the probable future composition of the energy supply; the likely distribution of economic activity and of local energy needs; and the probable future requirements for transmission and transport facilities in order to distribute supplies economically and take advantage of local diversity in plant and needs so as to increase the utilization of equipment that can be interconnected.

24. No mention is made here of a number of associated questions of major importance. Even the analysis of the existing energy economy from the stage of primary energy input to that of end-use consumption poses many problems not discussed. The order of priority to be accorded to different productive projects is also a complex question not easily resolved even in economically advanced countries. Because in newly developing areas the coming of supplies of electric power and other forms of energy can exert such a strong influence on demand, the aspect of evaluating, siting and linking-up the potential productive facilities may well merit as much attention at the outset as the analysis of the energy requirements themselves.

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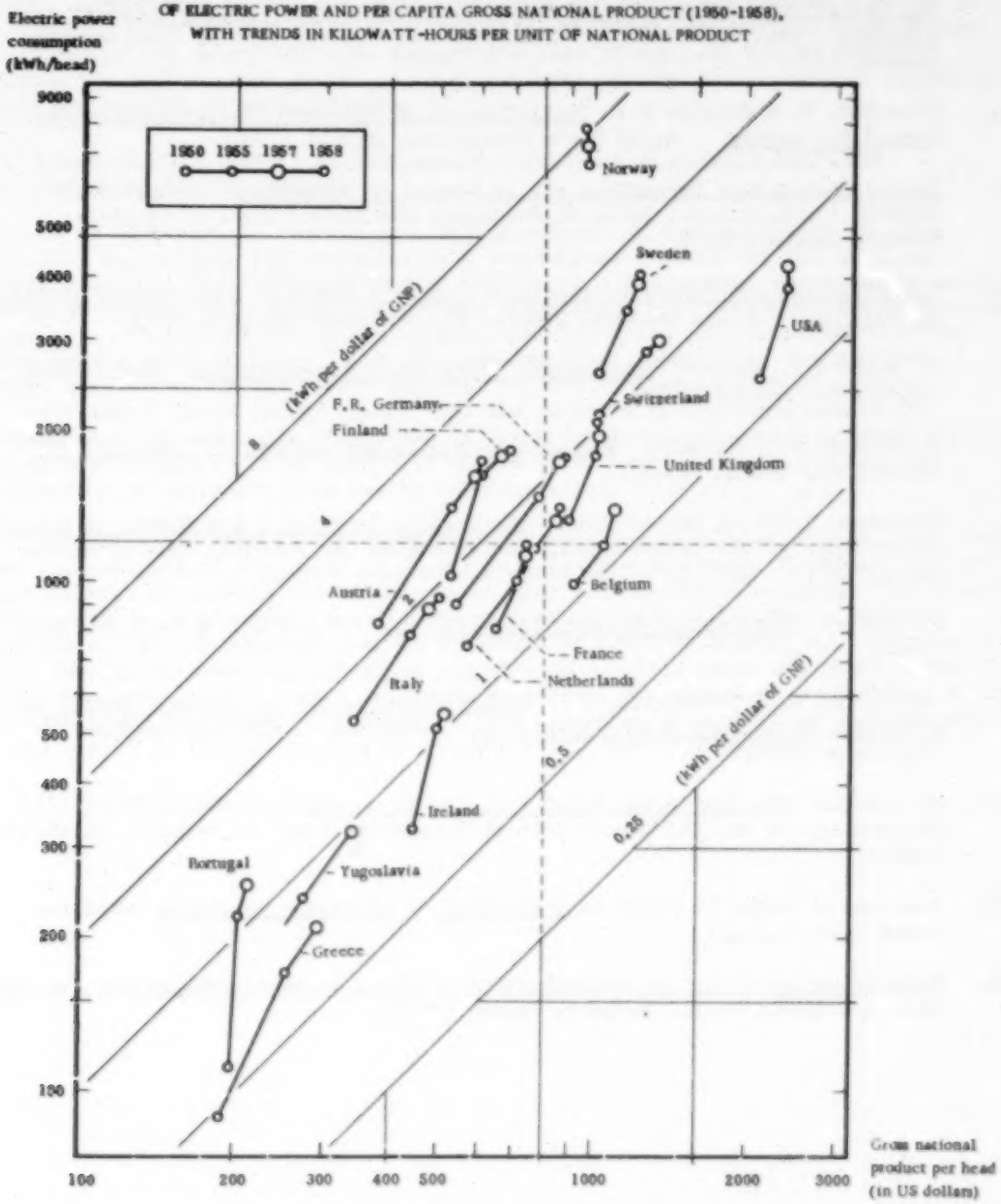
Figure 1

RELATIONSHIPS IN SELECTED COUNTRIES BETWEEN PER CAPITA GROSS CONSUMPTION OF ELECTRIC POWER AND PER CAPITA GROSS NATIONAL PRODUCT (1950-1958), WITH TRENDS IN KILOWATT-HOURS PER UNIT OF NATIONAL PRODUCT



NOTE: Gross national product is expressed in US dollars per inhabitant at constant (1954) prices.

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Agenda Item: A.5.1.4

Brazil

THE GEOLOGICAL EDUCATION PROGRAMME OF THE GOVERNMENT OF BRAZIL AND ITS RELATIONS TO NATIONAL SCIENTIFIC DEVELOPMENT

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4. Papers and summaries will not be available for general distribution in advance of the Conference. They will be published in advance in limited quantities only for the use of delegations of participating governments and of other authorized participants. Post-Conference publication and general distribution of the Conference Proceedings will follow United Nations practices as laid down by the United Nations Publications Board.

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The geological education program of the Government of Brazil and its relation to national scientific development

by

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1. Despite its very large territory and the relatively slight knowledge of its geology and its mineral, fuels, and water resources, Brazil was estimated to have only about 200 geologists in 1956, about only half of which were active in field work, research, or teaching. Up to that time geology was taught only in schools of mining engineering, and in schools of natural history located in faculties of philosophy of Brazilian universities. In recognition of the key role of the science of geology in national development and in view of the major shortage of professional geologists, the Minister of Education and Culture in 1956 designated a commission of the nation's leading earth scientists to study the problem. The findings of the commission were accepted by the President in the same year and early in 1957 the first new geology schools began their operations. The program is known as the "Campanha para a Formação de Geologos", (CAGE) or the Campaign for the Education of Geologists, of the Brazilian Ministry of Education and Culture, and is one of the largest and most ambitious efforts directed toward education of scientists in Latin America. It is hoped that the following description and analyses of its operation and effectiveness from 1957 through 1962 will be of use to other nations undertaking comparable activities.

2. Beyond its principal objective, an acceleration and improvement in geological education, the program was designed to fit both the cultural and physical environment of the nation and to effect some changes in the prevailing Brazilian university system that might have adversely affected the education of scientists.

3. The most fundamental decision of the study commission was the creation of geology schools that for a given period of time would remain independent of the university system. Although the university system is relatively new it is part of the Federal Government, with the exception of a few State universities, and its regulations are written into Federal law, resulting in considerable rigidity. For example, the law requires that each professional degree requires a specific curriculum of studies regardless of where the degree is taken. By establishing schools operating under special decree experimentation with geology curricula was possible. Membership of the governing board of CAGE consists of the Minister and the Director of Higher Education of the Ministry of Education and Culture and three geologists, which assures both high-level educational and administrative attention and the professional experience of several of the nation's leading geologists. This broad coverage would not have been possible had the schools been established in individual universities. The measure also permitted development of faculties that were not fully subject to university requirements

for establishment of special chairs. At the same time it permitted independence from local university administrative regulations and approval from the university governing boards that consist largely of older and well-established faculties. Upon development of their own faculties, curricula, facilities, equipment, libraries, and collections, the geology schools are to be transferred to universities and CAGE will go out of existence. In effect the Ministry of Education and Culture provided special support to the new schools to permit them to develop before being incorporated into existing institutions.

4. In most Brazilian universities faculty members devote only a small part of their time to teaching and the balance to their private professional careers. This leads not only to limited contacts between faculty and students but also to restricted personal research, which in science is not conducive to development of high-level faculties. To assure full-time application to teaching and research CAGE initially established faculty salaries at levels sufficiently high to avoid dependence upon outside sources of income. Student participation in most Brazilian universities similarly apt to be on a part-time basis, which also was considered to have an unfavorable effect. CAGE therefore provided sufficient financial support to enable students to complete their courses without recourse to intervening part-time employment.

5. One of the basic decisions of the study commission was to establish a group of small schools rather than one or two large ones. This seemed necessary because of Brazil's large territorial extent. Through this dispersion it was possible to recruit students from most parts of the nation and permitted more personal attention to students by the various faculty members.

6. The use of CAGE funds for publication was designed to overcome a unique Brazilian problem, the difficulty of obtaining scientific literature and textbooks in Portuguese. Despite the existence of a relatively large Portuguese-speaking population in the world, the small number of earth scientists tends to discourage publication by private companies of original texts or translations. The bulk of the text and reference material still is in English, and students are required to study the language in conjunction with their science courses. Several schools require study of a second foreign language.

7. With these preliminary steps and decisions taken and approved, CAGE came into being late in 1956 and four schools were founded in early 1957 in the following cities: Pôrto Alegre, State of Rio Grande do Sul; São Paulo, State of São Paulo; Ouro Preto, States of Minas Gerais; and Recife, State of Pernambuco. In 1958 a fifth school came into being at Rio de Janeiro, Distrito Federal, and in the same year the University of Bahia, at Salvador, opened a school independent of the CAGE system. Their development from 1957 through 1962 varied considerably. In part this was due to the facilities initially available to each of the schools, but a wide variety of other circumstances also were involved, some foreseen and others not. A major factor affecting the entire program was a serious inflationary spiral of the national currency that resulted in a far lower level of financial support than was intended. Notwithstanding, all schools are functioning. Three schools graduated their first students in 1960 and currently are producing about 125 geologists per year, a level that will cover the requirements of industry, government surveys, and research institutes and the assistants needed in the schools themselves. Although deficiencies of various types remain the schools are initiating steps that will lead to their full intergration into the university system. By and large, therefore, it can be said that the major objectives of the study commission and CAGE are geing attained, if not at the rate and fully in the manner originally anticipated.

8. A review of the various elements and factors may clarify the problems faced in an undertaking of this scale.

9. The facilities available to the various schools in 1957 and 1958 had a considerable range. Only two, the National School of Mines at Ouro Preto, and the Departments of Geology and Mineralogy at São Paulo, had been teaching geology as a minor for an extended period of time. Both had the nuclei of good geological libraries, small but reasonably good collections of rocks, and some basic equipment for classroom, laboratory, and field instruction, and both had excellent mineralogy museums. The Institute of Natural Science at the University of Rio Grande do Sul, founded only several years before CAGE, had the beginnings of a good paleontology collection and a small reference library, as well as miscellaneous equipment in some segments of geology. In contrast the school at Recife started with almost no facilities or equipment and had to build its libraries and collections from what was locally available. All suffered from acute shortage of space for classrooms, laboratories, and faculty offices and with the exception of Rio Grande do Sul, all occupied buildings that were not constructed or designed for school use.

9a. The two schools established in 1958, the one in Rio de Janeiro supported by CAGE and the one in Salvador supported by the University of Bahia, also had widely differing facilities. Rio de Janeiro is the site of various national geological and natural science institutions, principally the Departamento Nacional da Produção Mineral and the Museu Nacional, each with large libraries and collections. These, however, are scattered throughout Rio de Janeiro and space was obtained here and there. Bahia was the only school to start with a building designed for geological instruction, the result of remodeling an old mansion with the intent of furnishing the required rooms and and laboratories needed for all phases of operations. But Bahia, as Recife, was desperately short of library material, collections, and equipment. Beyond this none of the schools had sufficient vehicles to take students to the field.

9b. These initial shortages are slowly being overcome, largely through purchases of material from abroad. The rate of acquisitions is not as satisfactory as is desired by the faculties but little can be done to accelerate purchases, principally because inflation has resulted in prohibitive costs for imported equipment, texts, and other items. Domestic financial difficulties and government regulations also produce problems in acquiring materials nationally. Nonetheless field vehicles are being obtained, since they are manufactured domestically, and exchanges between schools have broadened all collections. The requirements for surveying equipment stimulated one Brazilian manufacturer to design and produce a telescopic alidade, and other items of field and laboratory equipment are beginning to come into domestic production.

10. The major problems still lie in importation of specialized laboratory equipment and supplies and printed material. The most difficult of these, largely unsolved, is the supply of reasonably-priced textbooks for students. It is being met in part by the preparation of textbooks by various Brazilian geologists, of which a half a dozen already have been printed. The financial support for their publication comes from various government sources; in addition to CAGE, the Departamento Nacional da Produção Mineral and the Instituto de Tecnologia of the Federal Government have provided funds, as have several State organizations. Several schools have begun scientific journals which are offered in exchange for foreign journals. During the last five years the U.S. Government annually has furnished about $20,000 worth of imported equipment, collections, supplies, and printed material, and international foundations also have allocated special equipment to several schools. Foreign professors have used their international contacts to obtain other items.

11. In one way or another space is being acquired, in part through purchases of nearby buildings, its allocation by universities, or through new construction. Plans for a new geology building are approved by the University of Rio Grande do Sul, the National School of Mines at Ouro Preto and the University of Bahia; construction of a geology building has begun at São Paulo, and the school in Rio de Janeiro is acquiring an adequate block of space in the new building of the Engineering School of the University of Brazil.

12. These very large requirements for physical facilities and equipment inevitably were the result of the decision to create a group of schools rather than one central school and the same difficulties applied to the development of faculties. With the exception of professors teaching basic sciences (including physics, chemistry, and mathematics) and drawn from existing faculties in engineering schools, the available geologic manpower was barely sufficient to staff the schools. As a consequence foreign geologists residing in Brazil were invited to join the new faculties and CAGE also contracted a number of professors from abroad. Several schools also invite distinguished professors from abroad to give short series of lectures in their specialties. The technical assistance agency of the United States Government signed an agreement to furnish 8 professors for a period of 6 years (1958-1964).

13. The school best prepared for the new program was São Paulo, which had been training graduates of the geology and mineralogy departments as assistants and professors since the end of World War Two; most of them had been sent abroad on scholarships for at least a year. The cooperative agreement between CAGE and the United States Government provided for an extension of the scholarphip program to all CAGE schools and other scholarships have been available to send young assistants to various countries for one or more years. Experienced faculty members have obtained grants to visit foreign universities both from agencies of the Brazilian Government and from abroad.

13a. With the exception of São Paulo other schools had great difficulty during their first years in obtaining graduate assistants, and as a consequence still have a gap in the staffing of the intermediate professorial posts. Beginning with the graduation of their first classes, all offered faculty positions to their better students. Rio Grande do Sul has been most active in sending its young assistants abroad.

14. The inflationary situation in Brazil has imposed still other stresses on the CAGE concept of faculty development. Currently few schools are able to offer sufficient salaries to attract further professors from abroad and these now on the faculties are finding it increasingly difficult to continue in their present activities. With a depreciation of the Brazilian cruzeiro to one-tenth its value at the time the schools were established, in terms of foreign exchange, salaries have not kept pace and even Brazilian professors are having trouble continuing on a full-time basis.

15. It should be added that the CAGE schools have been getting increasing financial support from the universities. Outside of Bahia, which from the beginning was fully financed by the university, São Paulo also has funds which go directly to its geology and mineralogy departments. Most other schools, have either gotten advances or direct funds to offset delays in appropriations or reductions in the CAGE budget. These procedures are also leading toward the consolidation of the schools into their future parent organizations.

16. The original concept of a flexible curriculum has been relatively satisfactory and has resulted in considerable changes from the initially-suggested program. Among the major changes was the development of field courses and the establishment of a senior thesis based on field work as a requirement for graduation. An even more important change is the pending suggestion to extend the curriculum from four to five years and to provide for optional courses permitting specialization during the last two years of the student's tenure. Among the options to be offered will be economic geology, petroleum geology, and engineering geology, the latter embracing specialization in hydrology.

16a. Both under the initially proposed curriculum and the present concept, academic work is highly concentrated and intensive. Students are expected to spend a full eight hours in classes and laboratories, attend week-end field trips, and to take field excursions and field courses during vacation periods. Either under the old or new curricula, the first year consists of basic science, drafting and language; the following years are devoted almost exclusively to the geology with the exception of a few courses in language or surveying. There has been some question whether this approach permits enough time for independent study or laboratory and library research but there can be no question that students are getting as much geology as possible within their school years.

16b. The overall didactic approach is that of producing professional schools and that it therefore differs from systems in use in other countries. One possible shortcoming of the approach is that the student must make his decision to enter the profession at a relatively early age and it also follows that some students find themselves in a field that may not be best suited either to their talents or their inclinations. The problem is compounded by one difficulty inherent in the Brazilian system of university education, the lack of facile transfer from one course of professional study to another.

16c. Regardless of the above-listed factors, the schools are producing graduates that have excellent backgrounds for careers in earth science. It has been asserted by some foreign professors. that the upper fraction of the graduating classes are equal to geologists holding Masters Degrees in other countries.

17. A few comments may be offered regarding students and student bodies. As in any part of the world, Brazilian students entering these geology schools are a product of their culture and their pre-university education. It is clear that pre-university education in Brazil varies greatly and it is also clear that the quality of student bodies reflect the quality of their high-school training. In those parts of Brazil where large numbers of good secondary schools exist the competition for entrance is higher, and such favorable areas also produce greater numbers of candidates. One facet of pre-university education in Brazil that mitigates to some extent against ready adaptation to scientific education is the general dependence upon rote learning and memory work. Although this permits larger absorption of required memory learning, it imposes extra responsibilities on those professors who must inculcate the very essence of geological education: scientific reasoning.

17a. Another factor involved in student development is that of academic discipline, which by and large tends to be rather loose in the student's pre-university years. During the first few years of the CAGE program several serious problems arose over this subject. Although some of these crises may

have been averted had school regulations been formulated and rigorously applied, the university student does have privileges and prerogatives that do not fit easily into such regulations. Most of these problems have been resolved and there is growing realization by students and student bodies that science requires a great deal of self-discipline of mind and action.

17b. The student, in addition to his traditional rights and a general measure of protection against failure or expulsion, also can rely on his very strong student organizations, which not only involve his class and his school but also his university; student unions beyond this point also are organized up to the national level. Because of this high degree of organization, student strikes are relatively frequent. Except in certain crucial cases the principal effect in the geology schools has been a fairly substantial loss of time in formal classroom, laboratory, and field instruction.

17c. Student-faculty relationships on the whole have been relatively good and the CAGE concepts of full-time attendance by both faculties and student bodies have led to greater communication than exists in most other segments of Brazilian universities. In only one instance during the period here described was there complete and extended conflict between the student body and the faculty of one of the CAGE schools; this situation eventually required direct invervention by the Ministry of Education. It should be added that the ultimate result was salutary in that greater effort and cooperation now exist than would have been possible during the normal course of events.

18. To summarize, CAGE has achieved to a relatively good measure in its original objectives and those deficiencies still existing are more the result of external circumstances rather than internal administration. Currently three faculties are in the process of assimilation into their associated universities and the school in Bahia is receiving good support from its parent institution. Several schools are considering the eventual development of graduate faculties.

19. Although the resources of Brazil were strained to develop this number of scientific schools simultaneously, there has been one additional and outstanding result, the establishment of six dispersed centers of geological research. Faculties practicing research and students working on their senior theses currently are producing more geological mapping than Brazil has enjoyed in many years and the various journals inaugurated by these schools are greatly increasing the production of geological literature and maps. This information already is being incorporated into the national knowledge and the results being used in the compilation of national maps. Coupling this school effort with the very large absolute increase in geological manpower, Brazil now is in a position where it will be able to staff its research organizations and to begin a significant attack on the enormous problem of studying the geology and resources of the largest nation in Latin America.

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